ENGINEERING

UNIVERSITY OF MICHIGAN
JUN 5 1959
ENGINEERING LIBRARY

UCTURAL ANALYSIS
DIGITAL COMPUTER

EGANT DESIGN

EARCH IN THE USSR
Bearings
ents and Prediction

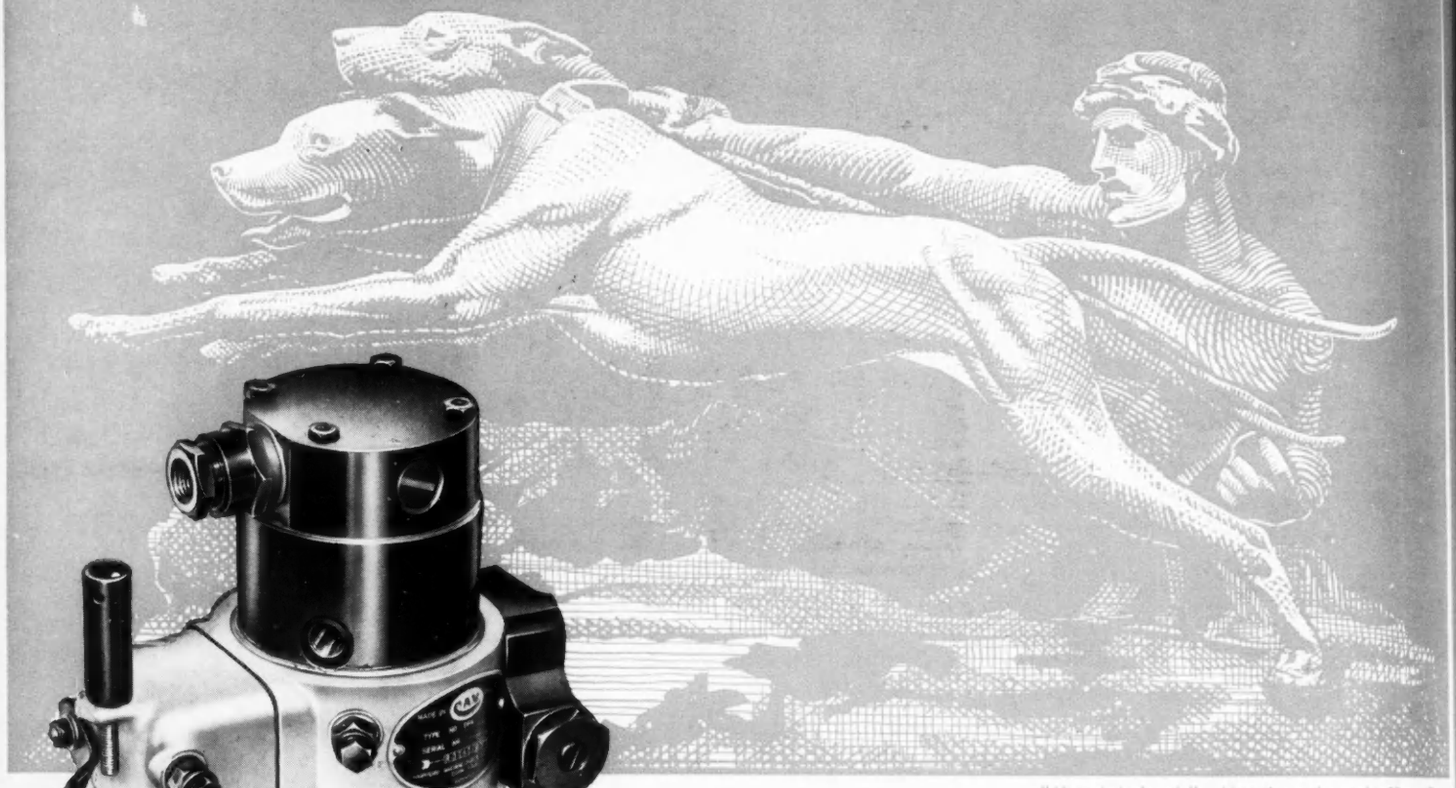
ESEL LOCOMOTIVE
ERATION

RE ABOUT
E NUCLEAR SHIPS

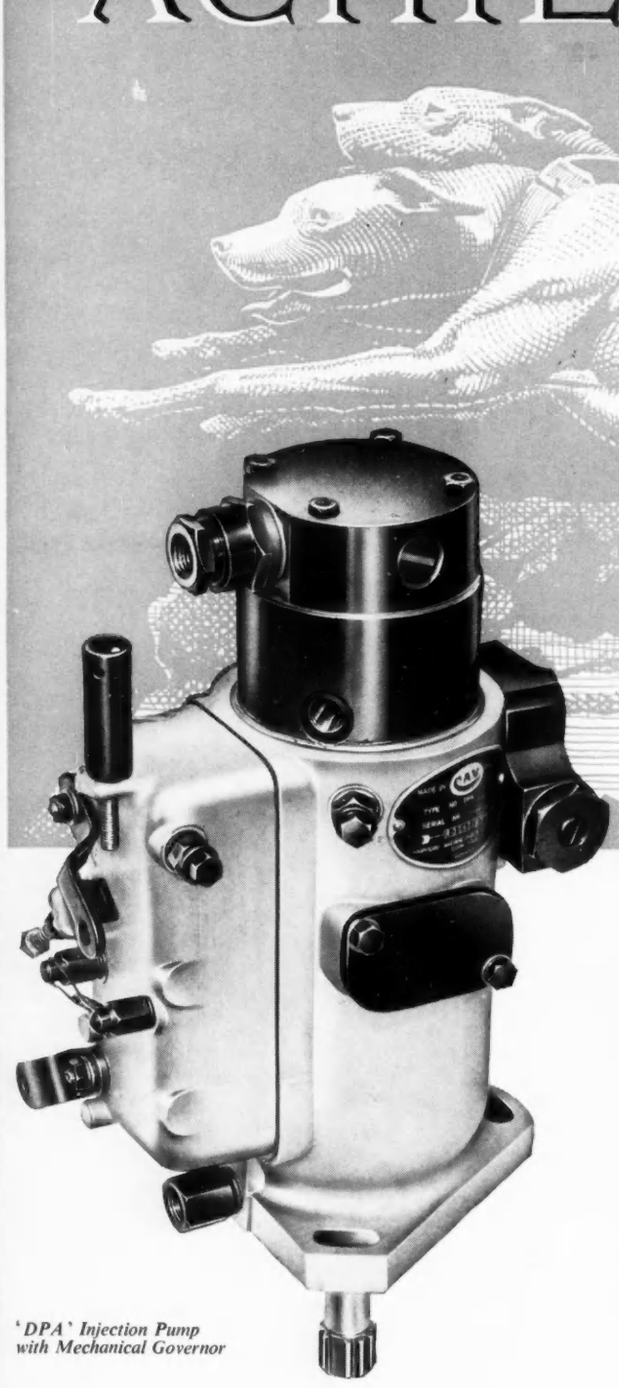
ERTIAL NAVIGATION
THE SOLAR SYSTEM

al Inspection

ACHIEVEMENT



"Hounds in Leash." After the sculpture by Harry Bates



'DPA' Injection Pump with Mechanical Governor

THE C.A.V.
DISTRIBUTOR TYPE
FUEL INJECTION PUMP
TYPE 'DPA'

The C.A.V. contribution towards the success of the lower-cost modern diesel engine—the 'DPA' pump, developed by C.A.V. research—has rapidly established itself in a premier position, 180,000 having gone into service in the last two years in all parts of the world. The 'DPA' pump offers many advantages—it is simple, light and compact, ideal for installation where space is restricted. It lends itself to the simplest and least expensive form of drive. It is suitable for high speeds, and needs no special lubrication. Supplied with mechanical or hydraulic governors.

The World's Leading Manufacturers of

FUEL INJECTION & ELECTRICAL EQUIPMENT

C.A.V. LIMITED, ACTON, LONDON, W.3.

AP 891

ENGINEERING

PUBLISHED EVERY FRIDAY

Vol. 187 No. 4863 22 May 1959

Contents

661 **Leading Article**
Clear Vision

662 **Plain Words**

662 **Weekly Survey**

663 **Letters to the Editor**
Electric Floor Heater
Home-Made Brake Tester
Architect and Engineer

666 **Special Articles**
Structural Analysis by Digital Computer: Better Designs Achieved Economically
Clearing House for Civil Engineering Computer Problems

668 **Companies in the News**

672 **In Parliament**

673 **Atomic Review**
Nuclear Ships in Context

676 **Automobile Engineering**
New Gas Turbine Engine for Motor Cars

680 **Meetings and Papers**

681 **On the Shelf**

681 **Publications**
The Potential Theory of Unsteady Supersonic Flow
Handbook of Physics
Digital Computer Components and Circuits
System Design of Digital Computers at the National Bureau of Standards

692 **At Home**
Elegant Design

. . . . . .

664 **New Plant and Equipment**
Cargo Winch, Crawler Crane, Industrial Ovens, Lead Measuring Machine, Ventilator, Circuit Breaker, Servomechanisms Tester, Live Roller Conveyor, Ballast Tray, Thrust Units

669 **The Human Element**

670 **Construction**
New Works in Hull Docks
Barking Flyover Completed
R.Ae.Soc. Lecture Theatre

677 **Research and Development**
Hydrodynamic Gas Bearings in the USSR
Ideas from the USSR: Patents and Predictions
Giant Hi-Fi Amplifier for Missile Research
Preparing to Launch the X-15
Inertial Navigation in the Solar System
Water Pollution from Factory Waste
Wind Power Generator Progress
A Semiconductor Tetrode
Why have Accidents?

683 **Metals and Materials**
Higher Working Temperatures for Cast Iron?
Pure Refractory Progress
Kilselguhr for Filtration
Asbestos Cement Sheet with Larger Span
Large Graphite Blocks
Du Pont Elastomers Expand Their Facilities
Catalytic Combustion of Exhaust Gases
Liquid Oxygen

685 **Design**
Lighthouse Equipment
Chair for Office Comfort
Universal Grid Matching Slotted Angle
Relief Valves for Power Circuits
Glueing Cartons at Differing Speeds
Four-Way Valve for Hydraulic Ram
Nuclear Reactor Controls
Scavenging and Cooling a 15,400 h.p. Marine Diesel
Hydraulic Screw Jacks for Ships Hatches

689 **Operation and Maintenance**
Diesel Locomotive Operation

690 **Production**
Printing Factory with Optimum Loading
Building on Work Study
Seeing a Picture 700 ft long
Power Station Efficiency

691 **Marketing**

ENGINEERING *Appointments Section faces page 676*

Clear Vision

THE sure, confident touch which has characterised many of the present Government's decisions and actions seems to have forsaken them in their preliminary study of space research. In his announcement last week the Prime Minister said he had " asked the Lord President of the Council, in consultation with the Minister of Supply and other Ministers concerned, to exercise general supervision of these new developments." In addition, the Royal Society shoulders a special responsibility since, according to the Prime Minister's statement, " the instrument programme will be supervised by the British National Committee on Space Research, set up by the Royal Society." These statements fail to make clear the precise lines of responsibility. It will be very surprising if, in a few years' time, there are not some awkward questions which cannot be satisfactorily answered.

British instruments, in a British container (or possibly an American one) are to be launched into space—probably by an American rocket under the supervision of American engineers. This is the gist of what was said at the press conference held by Lord Hailsham, Mr. Aubrey Jones, Professor Sir Edward Bullard, Sir Owen Wansbrough-Jones and Professor H. S. W. Massey. On the advice of Fellows of the Royal Society and the Advisory Council on Scientific Policy, the Government have accepted the proposition that space research is worthwhile in itself without having a foreseeable yield of practical results. Thus, pure space research is to be undertaken for its own sake, to the tune of several hundred thousand pounds, but with few or none of the practical benefits that the United States and Russia have enjoyed from such projects. If pure research is to be carried out on a national scale it should at least benefit industry and the economy generally by the development of new production techniques, new designs, and devices which may have practical applications.

A serious difficulty is to attempt to visualise any practical, commercial benefit from space research. There will certainly not be much from developing a few scientific instruments, and these possibly based on foreign designs. Profitable developments would only arise from a more extensive programme which included all the engineering aspects of satellite and space probe work. For purely military purposes we have already paid for the development of rockets which are said to be technically ready to launch a payload of 1,000 lb into an orbit some hundreds of miles above the earth. The heavy cost of pioneering satellite containers and many of the instruments has already been borne by other countries.

What we lack in large-scale resources of men and money is to a large extent counterbalanced by the ability to direct and carry out original work at a fraction of the cost incurred by the United States, and presumably the USSR too, though there is no means of checking. The cost of the rockets Black Knight and Blue Streak is said to have been low compared with the money spent on comparable projects abroad.

Apart from cost, however, the provisional statement of Government intentions suggests that " pure science " has been flaunted as the ultimate aim of space research. Of the long-term value of basic research, properly directed, there is no doubt, but a note of realism must be sounded. Mr. Charles J. McCarthy, chairman of Chance Vought Aircraft Incorporated, expressed it very well in the Wilbur Wright Memorial Lecture he gave in London last week:—

" Because of the fast moving pace of research, we must extend our vision and employ the greatest wisdom in the selection of business endeavours. The many paths opened up to management by the scientists present, at times, an almost bewildering number of choices. The tendency is either to spread efforts too thin or jump from one type of venture to another. Either of these approaches can lead to failure. A company must chart its course and then prepare itself for the technical weather that may be expected; and yet it must be sufficiently skilful that it can change its tack to take advantage of new situations as they arise. The coordination of company long-range objectives with proper guidance of research must occupy a good share of management's time. The selection of the proper areas of product development in the face of many possibilities requires the utmost in corporate judgment."

There is still a period of six months—the period estimated for the design study—during which the Government can seek advice and exercise wisdom in corporate judgment. Serious discussion of space research may sound so wildly imaginative that political masters of the art of the practical may have great difficulty in formulating their policy. But unless they come to grips with this problem, and give a clear sense of direction and purpose to everyone engaged in space research, much time and money may be wasted.

Cover Picture.—*Dimensions which have to be checked upon completion of a ship's propeller include pitch, diameter, track, blade width, spacing and thickness. Each propeller is an individual job designed and made for one particular vessel at a specified s.h.p and maximum revolutions.*

Plain Words

I was very glad to hear that the British typewriter industry are launching a drive to equip our homes with typewriters. The launching is to take place at the Business Efficiency Exhibition next week.

No doubt every inventor chafes at the conservatism of the human race. If only, he feels, they would take the trouble to understand what he is driving at, and perhaps learn a comparatively simple skill, motoring would be much safer, gardening would be easier or housework would be a pleasant half hour of relaxation. (Come to think of it, I have a pet idea myself: why can't we have motor cars which are washed down simply by coupling a hose from the kitchen tap to a connection, on the body of the car, which communicates via a number of passages with strategic outlets around the body? I feel sure this idea would not be beyond the wit of a plastics firm.)

I hope, therefore, that the British typewriter industry will have a large measure of success. The time will then be ripe to press for the teaching of typing at schools. There will be a vigorous protest, of course—overcrowded curriculum and all that. But I reckon typing should be one of the basic skills of every civilised person. It would be so easy—and such fun—to learn at school. It would be well within the mental capacity of a boy or girl, whereas some of the subjects taught at school cannot be adequately appreciated until adulthood. And I don't mean biology.

Then, of course, once we had won over the school teachers they would be ready to examine that machine, developed by a British electronics firm, which functions as an automatic teacher. The machine "feeds" the pupil with a stream of letters to tap out, and if he makes a mistake with, say, "k," the little box gives him rather more than the normal number of k's so that he can practice this letter. In case the human teachers are afraid of unemployment in their profession, I should explain that the pupil and the machine have to be supervised—a record of the pupil's performance is kept by the machine for inspection later.

Maybe American and Russian schools already teach touch typing to all their boys and girls. I don't know. But regardless of the practice in other countries a good case can be made out for it here. A rising proportion of the working population enter administrative work, and indeed the more advanced a nation, the more important is efficient communication. If I chose not to mention the fact, only our printers would know that this was written in longhand. Perhaps they will forgive me—I usually type. I am not a very fast typist—but I didn't learn how until well into adulthood.

CAPRICORN

Weekly Survey

Harmony of the Spheres?

There is a touch of irony in the latest announcement on space research. Last week this country announced its initial space satellite programme with its heavy dependence on cooperation with the United States—and on Russia too to judge from minoritory comments in the House. Last week also saw the agreement between the United States and Canada on a scheme to launch the first Canadian space satellite from California in about two years time, an announcement which coincided with the news that the United States has ordered eight moon rockets at a cost of £12 million. These eight Vega space rockets are to be built by the end of 1961 and are intended to explore the moon and the nearer planets.

Meanwhile, at a more mundane level, space research cooperation has run into political complications. Last week Russia, Poland and Czechoslovakia boycotted the United Nations 18-nation committee on peaceful cooperation in outer space. Two other countries, India and the United Arab Republic, therefore decided not to attend either, since one of the leaders in space exploration would not take part. Despite these trestrial complications the committee went on to form two study groups one to deal with the legal aspects and the other with the scientific aspects of space exploration. The chairman of the committee, a Japanese delegate, said that the committee, which was set up by the General Assembly last year, would be the first step "in carrying out humanity's determination that outer space will have peaceful, orderly and international development." These aspirations along with space research and exploration are now well ahead, it would seem, of the political intelligence of the human race.

How Your Company Stands

Pioneer work on interfirm comparisons has been done in this country by isolated industries and companies and has been stimulated by the British Institute of Management. The BIM now announces that it is setting up in association with the British Productivity Council, "The Centre for Interfirm Comparison." This new organisation will have its offices at Management House and it has been formed to meet the growing demand from trade and industry for an independent specialist body to carry out such comparisons as a service to management.

The BIM has already established contacts with international organisations interested in these studies, such as the European Productivity Agency of the OEEC in Paris and with national bodies in Western Europe and in the United States. Through these contacts the new centre will be able to offer an international interfirm comparison service to British industry. Interfirm comparisons give management key figures showing how its operating performance and financial results compare with those of similar organisations in the same industry or trade, all having first contributed figures to a common pool. These figures are given anonymously and in the strictest confidence. So far as the new centre is concerned, at no time will the name of a concern be disclosed to another or to any outsider, all taking part will be known by a code number and information submitted will be treated in the strictest confidence. The centre will carry out comparisons by direct arrangement with individual concerns or will offer special services to trade organisations.

The new centre will include an advisory service and a programme of courses, seminars and conferences throughout the country on management ratios and interfirm comparison. Some of these will be of a general kind and others for particular industries. The first programme of seminars includes meetings in London, Liverpool, Manchester, Coventry, Sheffield, Glasgow, Leeds, Cardiff and Nottingham.

Plastics by the Ton

In 1958 sales of plastics at 415,000 tons were 6 per cent above the 1957 level. In overseas trade, exports of plastics have gone up steadily over the past four years from 73,300 tons to 120,000 tons. Exports to the European Common Market countries have almost doubled during this period and now stand at over 25,000 tons. At the same time imports of plastics have gone up by some 30 per cent to over 44,000 tons. The value of plastics exports in 1958 according to the British Plastics Federation was some £32 million. Of the two main types of plastics, thermoplastic and thermosetting the former have grown the more rapidly.

Thermoplastics are the compounds that can be resoftened for manipulation. One which is very familiar and has a wide range of uses is polyvinyl chloride generally known as pvc. Over 100,000 tons of pvc were produced in 1958. This is followed by polyethylene, 65,000 tons, polystrene 33,000 tons and acrylics 15,000 tons.

The thermosetting plastics cannot be remoulded once they have set. The principal types in this group are phenolics, of which 66,000 tons were produced last year. These are followed by aminoplastics 52,000 tons, alkyds 46,000 tons and polyesters 5,000 tons.

Apart from the materials already on the market several new ones are in process of development. One which is said to have a great future is polypropylene. This is a thermoplastic which like polythene belongs to a group of materials known as the polyolefins. All told, the British plastics industry is doing well but there are two small clouds on the horizon. The first is the danger of domestic overproduction especially when established and new materials are being produced at the same time. The other is the indication from the import figures that increased foreign competition is to be expected.

United Kingdom Oil Capacity

Last year the output of refined products from Britain's oil refineries rose to nearly 30 million tons. This represented an increase of 18 per cent over the 1957 figures which had been affected by the Suez affair. Over the past ten years oil refining in Britain has expanded sevenfold. The main capital investment programme involving some £200 million was completed by 1954. Of last year's crude oil imports 46 per cent came from Kuwait. Most of the remainder was equally divided between Iraq, Persia and Venezuela.

The industry now has eight main refineries and a number of smaller ones. The biggest is Esso's Fawley refinery with a throughput of 10·5 million tons a year. The others in order of size are Shellhaven (Shell) 8·0 million tons, Isle of Grain (BP) 7·2 million tons, Stanlow (Shell) 5·5 million tons, Grangemouth (BP) 3·2 million tons, Llandarcy (BP) 3·0 million tons, Coryton (Mobil) 1·87 million tons and Heysham (Shell) 1·35 million tons. In addition there are smaller plants with an aggregate capacity of 600,000 tons at Ardrossan, Pumpherston, Manchester and Ellesmere Port. In round figures Shell has a total annual capacity of about 15 million tons, BP about 13½ million tons, Esso 10½ million tons and Mobil nearly 2 million tons.

New plants now under construction are the

Esso refinery at Milford Haven with a capacity of 4·5 million tons a year, and the BP tanker terminal there to serve Llandarcy. The Caltex project for a refinery at Hook on Southampton Water has met with considerable local opposition and it is not at all clear where this particular plant will eventually be built.

Piping Oil in Britain

Pipelines have not hitherto been laid in this country for the commercial transportation of petroleum products partly because few areas of the country are far from a port and partly because of the absence of sufficiently large centres of consumption. The stage is approaching, however, when owing to the rapid growth in demand for petroleum products and the growth in refinery capacity, pipeline transportation may become economic to some of the largest centres of consumption.

Work has begun on 6 in and 8 in lines to be laid over a distance of 23 miles from the Shell refinery at Stanlow to a storage and distributive centre at Partington, near Manchester. The whole project, which will have a storage capacity of 70,000 tons, will cost about £2,250,000 of which about £1 million is attributable to the pipelines. Shell-Mex and BP Limited consider that this expenditure will be justified by the reduced costs and improved efficiency of distribution. A proposal has also been put forward for a pipeline to London Airport to meet the growing consumption of aviation fuel.

As a result of siting the refineries on the coast, there is virtually no transport of crude oil excluding Finart and pipeline development is unlikely to reach the level prevailing in the United States, where about 40 per cent of the total consumption of crude petroleum and petroleum products are piped. On the Continent, pipelines of considerable length have been laid or are projected for the transport of crude from Mediterranean or North Sea ports to refineries located in the Ruhr and other industrial centres.

German Oil Port

West Europe's fuel and energy policies are becoming increasingly difficult to understand. At a time when the High Authority at Luxembourg is at its wits end to know what to do with surplus coal stocks, new pipelines are being constructed to bring oil into the heart of the industrial areas and further depress the demand for coal. The latest of these is the Nord-West Oelleitung, Germany's first major oil pipeline which is now pumping crude oil 250 miles from the new oil port at Wilhelmshaven on the North Sea to refineries in the Ruhr and Cologne areas.

Wilhelmshaven, thanks to its new oil jetty and installations, is now capable of handling 100,000 ton tankers. The other ports able to do this are Milford Haven, Le Havre and Rotterdam. At present the jetty can take about 300 tankers a year but this number will be more than doubled when further construction work is completed next year. At the other end of the pipeline the four refineries operating in the Ruhr-Cologne area are planning to increase their combined annual throughput from 5½ million to 11 million tons. Five new refineries with a total throughput of 21½ million tons a year are now being built.

The initiative in the construction of the Wilhelmshaven oilport and the north-western pipeline was taken by Esso, which holds 47 per cent of the capital in the company operating the pipeline. Other partners in the venture are BP of Hamburg, Purfina of Duisburg, Ruhrchemie of Oberhausen, Scholven-Chemie of Gelsenkirchen and Union Rheinische Braunkohlen Kraftstoff of Wesseling. The eventual total cost of the oil port and pipeline is expected to work out at from £20 million to £25 million.

Natural Gas Repercussions

The experiment of bringing a cargo of frozen natural gas to Britain last February in the Methane Pioneer has been criticised in the House of Commons as untimely in view of soaring stocks of coal. Elsewhere, reactions have been of a very different kind. In Venezuela plans for shipping gas across the Atlantic are said to be well advanced. The advantages of doing so are obvious in a country which flares off some 600,000 million cu. ft of gas a year. This works out at more than double the United Kingdom's current total supply of town gas from all sources.

A Venezuelan concern, Gases Licuados Constock, has plans ready for setting up gas liquefaction plant. These proposals are not likely to be carried further unless there is some assurance of a substantial and continuous demand. At the moment the required demand is unlikely to be forthcoming in the sort of volume that would justify the heavy costs involved in building the gas liquefaction, refrigerated storage, pipelines, compression plants and the highly specialised gas-carrying tankers. One important and largely incalculable factor is the well-head price of the gas itself, as most of the gas that might be shipped is at present going to waste. The Constock company has offered 7 cents per 1,000 cu. ft for some Venezuelan gas. Other concerns are offering 10 cents.

In Mexico hopes of exporting natural gas have also been raised, and the state-owned Pemex concern has plans in hand for the necessary installations. In the United States the reaction to the Methane Pioneer experiment has been sudden awareness of the danger of new competition to the home natural gas producers. Tanker-borne natural gas from Latin America or the Middle East would be as attractive on the East Coast or Western Seaboard of the United States as it would be in Western Europe. All sections of the gas industry are now cooperating in a study of the effects of this new source of competition. All told, it looks as though the Methane Pioneer has touched off a whole series of reactions both positive and negative, that the originators of the experiment probably never anticipated.

Electricity on the Roads

Less is heard these days than formerly about battery-electric motor cars. Nevertheless, according to the annual report of the Electric Vehicle Association of Great Britain issued last week, there has been a flurry of interest in the subject following the visit of a director of the Atlantic City Electric Company from America whose visit was mainly concerned with the possibility of producing commercially battery-electric passenger cars. The idea has for long had an appeal in terms of absence of petrol fumes and the ability to run a large fleet of such cars off batteries which could be charged, to some extent at least, in off-peak periods. One such vehicle, the TEL car, was described in ENGINEERING for 27 March, page 393.

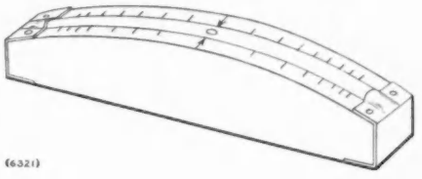
Battery-electric vehicles have made steady if unspectacular progress in such fields as conveying and handling. At the end of 1958 there were about 35,900 battery-electric vehicles in use in Great Britain and Northern Ireland compared with about 34,850 at the end of 1957. New registrations of battery-electric vehicles in 1958 amounted to 2,293 of which 338 were exempt from road fund licence. These figures are small compared with the road vehicle population as a whole. In September, 1958, vehicles licensed on the roads of Great Britain amounted to 7·9 million of which 4·5 million were cars. There were 7·4 million vehicle licences current in September, 1957, and the recent annual rate of increase has been about 7 per cent. This compares with a rate of increase in battery-electric vehicles between 1957 and 1958 of only 3 per cent. The gap is, therefore, not only huge but growing.

Letters to the Editor

HOME MADE BRAKE TESTER

SIR, The article on page 612 of your issue of 8 May, about a brake tester/accelerometer costing £12 12*s*, reminds me of one which any handy craftsman can make for nothing—or nearly so. I made one in 1913, following a description given in some technical journal. I was working at the time on London railway lectrifications, and was seeking a correlation between the behaviour of straphangers and the braking retardation.

The accompanying sketch shows what it looked like. Placed conveniently on the window sill of a railway coach one can investigate braking and acceleration figures unobserved.



In a steam train—in a coach near the engine—one can see every stroke of the piston. Unfortunately, it was lost in the blitz, with all my other workshop equipment; but I learned a lot from it.

The sensitive element is a ¼ in glass tube, bent to a suitable curvature (a cycloidal curve gives a nice spacing of the graduations) filled with water except for a small air bubble, and sealed off at both ends. The size of the bubble determines the degree of damping, and a few trials may be needed to get it right. The tube is mounted in a wood block, with thin metal caps at the ends to hold it in place.

Calibration is dead accurate and dead easy: a slope of 1 in N is g/N ft per sec² acceleration. I calibrated mine in ft per sec² on one side and slope on the other. Apart from a " book mark " pointer it did everything that the one described could do, and being only about 5 in long could be carried in one's pocket. To give it better stability I hollowed out the base and filled it with lead, and lined the bottom with coarse emery cloth to give a grip on the surface it was resting on.

Yours faithfully,

HUGH CLAUSEN.

17 Harman Drive,
London, NW2.
9 May, 1959.

ELECTRIC FLOOR HEATING

SIR, On page 592 of your issue of 1 May last, you published extracts from Mr. H. H. Bruce's paper to the Institution of Heating and Ventilating Engineers entitled " Off-Peak Floor Heating."

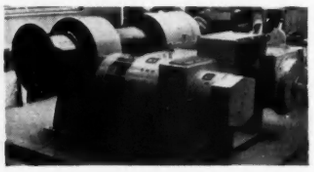
This paper was like a performance of Hamlet without the Prince. It started with a short but welcome pat on the back for the enterprise and courage of the electricity Boards and continued with a lengthy criticism of electric floor warming, thus paving the way for an account of a new method of " off-peak " electric heating that would have all the virtues and none of the defects.

Having thus wetted our appetites we were informed that no details of the system could be given and with this we had to be satisfied; Hamlet never left the shelter of the wings!

Would it not have been better if Mr. Bruce had waited until he was able to give some details of his new system so that his audience could judge for themselves whether it would, in fact, fulfil all the claims made for it and be entirely free from wishful thinking? As it is, one only has Mr. Bruce's opinion of the merits of his system to set against the fact that something over 5,000 flats with electric floor warming are either

CARGO WINCH

Automatic Speed Control According to Load



A CARGO winch for an alternating current supply has been developed by Stothert and Pitt and incorporates a Mawdesley Ward-Leonard set with automatic excitation control.

Special advantages claimed are that the various speeds are obtained automatically, both hoisting and lowering, without the use of load discriminators and contactors.

Dynamic braking is employed on all lowering notches and the electromagnetic disc brake is only used for holding the load in the "off" position. No foot brake is needed. When on cargo duty the only parts in operation are the field contactor, the brake contactor and master controller.

As no high current peaks are imposed on the supply mains under normal cargo duty, high capacity generating plant is not required.

The control system is basically a conventional Ward, Leonard scheme but the winch motor field and the generator field are controlled simultaneously. This is done by adding to the conventional Ward-Leonard system an exciter with a special characteristic which is determined by the value of the current in the armature loop circuit. A rectifier is also fitted to provide constant excitation.

The control gear comprises a push button-operated direct-on starter for the motor generator set, a hand operated master controller, and a small control panel, which embodies a field contactor, a brake contactor, an overload relay and rectifier equipment. The control gear is all mounted in a watertight casing, either bolted to the winch bed or as a separate unit. The winch itself is made as a self-contained unit (when the control gear is built in) and is of the worm geared type. In the standard form it has a centre barrel and two whipping drums. *Stothert and Pitt Limited, Bath.*

CRAWLER CRANE

Cantilever Jib for Long Reach

THE NCMT crane is a cantilever jib version of the Neal NS45, with 4 tons capacity and mounted on a crawler chassis.

The crane has full circle slewing and is said to be particularly suitable for construction work as it can be brought up close to any building and the long reach of the jib enables it to cover a very wide area. Three ratings quoted are for 12 cwt at 43 ft radius with a lift to 25 ft; 20 cwt at 22 ft radius, the lift then being 57 ft; and 20 cwt at 9 ft 6 in radius to a height of 61 ft.

Power to drive all the motions is supplied by a heavy duty two cylinder radiator cooled Lister diesel engine type FR2. An electric starter is fitted as standard. The superstructure is mounted on 16 in crawler tracks.

All loads can be safely handled through the full slewing circle of 360°, turning in either direction. A radius indicator is fitted to show the maximum permitted loads at each position.

The hoist, slew, derrick, and travel motions are independently operated and can be in either direction. The travel mechanism is operated by a dual clutch system with two pedals. Instantaneous reversal of direction can be obtained without gear changing. *R. H. Neal and Company Limited, Plant House, Ealing, London, W3.*

INDUSTRIAL OVENS

Gas Fired, Tray Loading Models

STANDARD sizes in a new range of gas fired, tray loading industrial ovens are from 8 to 72 cu. ft capacity. All include safety features recommended by the Gas Council and HM Factory Inspectorate.

The ovens can have either vertical or horizontal forced air circulation or natural convection, and they can be supplied for direct or indirect firing. Automatic temperature control is standard.

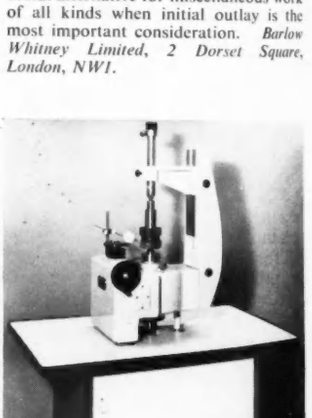
The range covers four types. Series GD. 300 V.A.F. are direct fired units in which the products of combustion pass through the working space. They have vertical forced air circulation and operate at temperatures to 300° C. Series GD. 300 H.A.F. are similar in construction but have horizontal forced air circulation.

Series GIN. 200 V.A.F. have indirect firing, the products of combustion being excluded from the working space. With this series the temperature is adjustable to 200° C, and forced air circulation of the vertical type is used.

Series GD. 300 are direct fired units for temperatures to 300° C with natural draught convection. They provide a useful alternative for miscellaneous work of all kinds when initial outlay is the most important consideration. *Barlow Whitney Limited, 2 Dorset Square, London, NW1.*

LEAD MEASURING MACHINE

Bench Mounting Model



A BENCH mounting machine has been introduced for the purpose of measuring the leads of helical gears of the sizes usually met with in the automobile, aircraft, and machine tool industries.

The maximum size of gear that the machine will accommodate depends somewhat on the shape, and on the arbor used. In general gears up to 5 in radius and 10 in depth can be checked, but the lower centre can be withdrawn to give a distance of 17 in between centres for gears on shafts. The maximum helix angle recommended is 45°, but this may be reduced for very small gears. The diametral pitch should not exceed 24, nor should the weight exceed 100 lb.

The generating mechanism uses gauge blocks for sine bar setting, and the error is shown on a dial gauge. A hook type stylus is available for internal gears. An alternative attachment is a combined indicating and recording head using a Mercer Precimeter and a Talymin pick-up With a Magna-Gage and pen recorder magnifications up to 4,000 can be obtained; other recorders can also be used. *J. Goulder and Sons Limited, Kirkheaton, Huddersfield.*

Continuing Letters to the Editor

completed or under construction in this country.

It would not be possible to answer all Mr. Bruce's criticisms in a letter but most, if not all of them, were dealt with during the discussion, including the case of the Hawkesley Farm Moat flats, Birmingham, where it was alleged that only one tenant in the block was using the floor warming system, whereas in actual fact at the time the paper was read, all the tenants were using their floor warming system.

May I suggest that in fairness to electric floor warming you publish some suitable extracts from the discussion on this paper?

Your faithfully,
E. M. ACKERY,
Senior Technical Officer.

British Electrical Development Association,
2 Savoy Hill,
London, WC2.
13 May, 1959.

Editor's Note.—We hope to discuss the subject again. The Institution of Heating and Ventilating Engineers are planning to publish Mr. Bruce's paper and the discussion in the July issue of their journal.

ARCHITECT AND ENGINEER

SIR, I usually find myself in agreement with Capricorn and never more so than when, in your issue of 8 May, he castigates those architects who exhibit drawings of engineering works with which they have been associated without acknowledging the name, or even the existence, of the engineer. It is indeed surprising that the RIBA, which is usually rather careful about professional ethics, has not taken steps to discourage this deplorable practice.

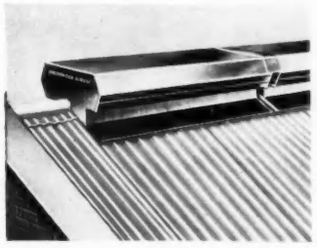
But I hardly expected you to follow suit! In the very same issue, on page 610, is an account of the very interesting "music bowl" at Melbourne. This remarkable structure contrives, by an ingenious system of prestressing, to cover 2,000 people and yet to have only two compression members. The architect, we are told, was Mr. Barry Patten; but who, pray, was the engineer?

Your faithfully,
J. A. L. MATHESON.

The University,
Manchester 13.
15 May, 1959.

Editor's Note.—Professor Matheson raises a valid point. The name of the engineer—if there was an engineer as well as an architect—was not included in the information available to us at the time.

VENTILATOR
For Ridge Line Fitting



THE Greenwood-Airvac ridge line extractor is designed to give permanent or controlled ventilation for industrial buildings.

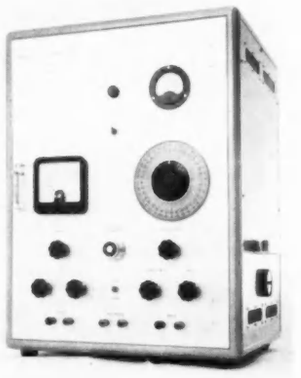
It is claimed that the large unrestricted free outlet and the aerodynamic design use the natural stack effect of the building to give maximum extraction rates. The baffles are arranged to make the whole unit weatherproof.

The extractor rises about 9 in above the line of the roof ridge and there are two lengths of standard unit: 3 ft 10 in and 5 ft 10 in. There are end terminal units for fitting to long runs. All units are made in hardened aluminium and will not corrode.

Manually controlled or thermostatically operated motorised dampers can be fitted and are recommended where heat conservation in winter is of importance. It is claimed that these dampers do not add any restriction to the flow when they are in the fully open position. A fusible link can be incorporated to open or close the dampers automatically in the case of an outbreak of fire within the building.

Performance figures quoted for the extractors operating under normal conditions are: for a height of 10 ft above the air intake to the building and a temperature difference of 10° F between the inside and the outside, the smaller size will remove 68,500 cu. ft per hour; for a height above intake of 50 ft and a temperature difference of 50° F this figure rises to 174,500 cu. ft per hour. For the larger size the corresponding figures are 102,000 and 267,000 cu. ft per hour respectively. *Greenwood's and Airvac Ventilating Company Limited, Beacon House, Kingsway, London, WC2.*

SERVOMECHANISMS TESTER
Transfer Function Analyser



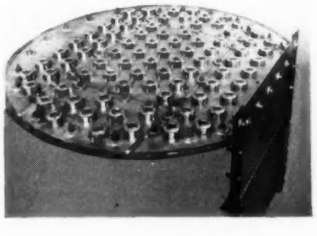
THIS range of transfer function analysers has been introduced to provide a stable and accurate means of testing servomechanisms and control gear.

The chief claims are: the electromechanical system employed is accurate and free from drift; the equipment is insensitive to harmonic distortion introduced by the system under test; direct indication of amplitude and phase angle is given; alternating current operated servo systems can be tested directly; performance of modulators and amplifiers can be investigated; the instrument can be direct coupled to mechanical and hydraulic control systems without the use of actuators; and the equipment is self contained.

The instrument is housed in an aluminium alloy cabinet the front of which is hinged to allow access. The two vertical chassis which carry all the electronic circuits are accessible from the sides without being removed.

There are three models in the series, with frequency coverage from 0·02 c/s to 250 c/s; the d.c. and a.c. output signals are 30 V 10 mA max and the output torque varies from 15 to 1 oz-in according to frequency. *Servo Consultants Limited, 17 Woodfield Road, London, W9.*

BALLAST TRAY
Mixing Unit for Distillation Columns



IT is claimed that the Glitsch ballast tray incorporates the advantages of both the bubble-cap and sieve trays without their weaknesses.

The tray can roughly be described as a bubble-cap tray in which the cap and riser assembly is replaced by a unit which produces constant vapour velocity through a slot. It can also be described as a sieve tray with the apertures sealed at zero vapour flow rates. Other claims include its robustness and its low cost.

Each ballast unit consists of a fixed travel stop enclosing a ballast plate, and below that an orifice cover. Increasing vapour pressure lifts the last named first (allowing the vapour to flow into the upper chamber) and then with continued increase, the ballast plate, until the maximum annular aperture is gained. A "turn-down" ratio of at least 9 : 1 is possible, giving a very wide working range of vapour flow.

Since the tray assembly is lighter than a corresponding bubble-cap tray, tray floors and supports can also be made lighter. The wide flow range allows smaller towers to be used. However, the tray can be used with existing tower rings and downcomers offering direct replacement in existing structures and giving increased capacity without increase in plant size.

The violent turbulence of the vapour coming out of the annulus gives good mixing and also renders the tray virtually self-cleaning.

There are said to be no dead areas on the tray, and as there is only point contact between the components of the ballast unit, sticking does not occur. *Metal Propellers Limited, 74 Purley Way, Croydon, Surrey.*

CIRCUIT BREAKER
Flameproof Hand Operation

THE type SBU.1 is a hand-operated air-break circuit breaker designed in accordance with NCB Specification P 7/1950 and is certified flameproof for Group 1 gases.

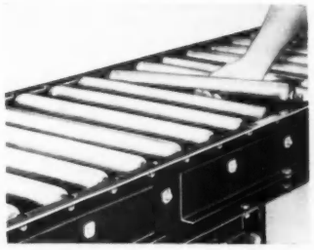
The housing comprises a welded steel case divided horizontally into two flameproof compartments. The upper, smaller compartment contains the triple-pole isolator which is mechanically interlocked with the door of the main compartment.

The circuit breaker and its protective gear are housed in the lower main compartment and mounted on a withdrawable chassis which can be removed from the enclosure on slide rails.

The breaker is continuously rated at 200 amperes. It has a breaking capacity of 9,000 amperes at 650 volts, 0·25 power factor, equivalent to 10 MVA, and a making capacity of 21,200 peak amperes at 650 volts.

Overload protection is provided by a two-pole self-resetting solenoid relay, with two-rate time delay. An under-voltage relay is fitted. Earth leakage protection is provided by a d.c. relay energised from a ring-type transformer through a full-wave rectifier; an intrinsically safe lock-out circuit ensures that, if the breaker trips because of an earth fault on the outgoing cable, the breaker cannot be reclosed until the fault is removed. Remote tripping and electrical interlocking can also be provided. *The Belmos Company Limited, Bellshill, Lanarkshire.*

LIVE ROLLER CONVEYOR
Pop-Out Rollers



THE Rapistan live roller conveyor is intended for applications where loading, unloading and sweep-off operations are required at intermittent points along the line.

One of the main features is that the carrier rollers have their axles running free in slots so that if any object should come between them and the drive belt, they will lift clear and so prevent damage. Under no-load conditions they run light on the belt and the conveyor virtually idles, but as the load is applied the pressure is passed on through the belt to the pressure rollers below. Thus the greater the load the greater is the driving force available.

Both carrier and pressure rollers are made of 13 gauge welded steel tubing with free running prelubricated ball bearings pressed into the ends. The rollers are supported on $\frac{7}{16}$ in hexagon axles. The pressure rollers are mounted through an elongated hole in the frame into an adjustable angle plate so that they may be raised or lowered to obtain the optimum belt pressure against the carrier rollers for maximum working efficiency. Each standard 10 ft section of conveyor has two sets of three pressure adjusting plates. Idler rollers carry the driving belt on its return path.

The standard running speed of the conveyor is 65 ft per minute, but other speeds are available by using different size drive pulleys and V belts. A range of motors is available to cover various horse power requirements. The surface of the carrier rollers is smooth to minimise frictional resistance when stopping or sweeping off materials. *Manufacturers' Equipment Company Limited, Sutton Road, Hull.*

THRUST UNITS
Self-Contained Electromechanical Drive

A STANDARD range of self-contained electromechanical thrust units has now been put on the market under the trade name "Autoram."

Available in various sizes, they are to be offered as alternatives to solenoids and hydraulic, compressed-air and vacuum-operated cylinders. They have the advantage that they can be operated directly from standard a.c. electrical supplies, using standard types of switchgear.

Each unit incorporates an electric motor, totally-enclosed reduction gearing, and a ram which is extended or retracted by means of a screwed shaft and nut mechanism. A limit switch device is normally fitted to control the stroke.

Units are available in various sizes, suitable for thrust loads from 0 to 5,000 lb with maximum stroke lengths to suit users' requirements. They are available for foot, flange, or trunnion mounting. *George Angus and Company Limited, 152-158 Westgate Road, Newcastle upon Tyne 1.*

STRUCTURAL ANALYSIS BY DIGITAL COMPUTER

Better Designs Achieved Economically

By M. B. ABBOTT, B.Sc. (Eng.)

Formerly Lecturer, Southampton Technical College

The high speed digital computer is of considerable potential importance in structural engineering. Present methods of structural analysis, having been developed for human hand and brain, are not satisfactory for automatic computation; new methods of analysis may utilise the assets of the machine to much greater advantage. Considerable changes in structural analysis may be expected and also changes in the structures themselves.

Influence upon Analysis

It is possible to distinguish two definite influences on the present development of structural analysis. There are the architectural demands for new forms of structure and there are the ever present demands for economy. These influences have both stimulated interest in automatic computation.

The first of these is especially well illustrated in the case of thin concrete shells. Here the architectural needs for a certain sort of structure have stimulated considerable advances in analysis. These advances have in turn engendered computational needs which can only be met by the high speed digital computer.

Though many important new buildings utilise thin shell roofs, the number of such designs remains small compared with the number of designs for conventional steel or reinforced concrete frames. Such frames can be analysed without automatic machines, but the demands for more rational and economical structures has led to the development of new methods, principally plastic design methods, where the digital computer is, again, a necessary adjunct to further advance.

An essential step in the development of any new method is its application in practice. If this application is to be made successfully, and if practice is to develop its own methods, then a more widespread appreciation of the role of the digital computer is required.

When first introduced the computer was regarded very much as a "super slide-rule"—a machine which merely followed the same routine as was previously followed by human hand and brain, but which did so very much faster. Though in this guise it presented certain attractive features, doubt existed, and still exists, as to whether the advantages balanced out the cost for most practical purposes. These advantages may certainly be very dearly bought if the computer is regarded in this way, for such an attitude can easily lead to a quite incorrect employment of the machines' facilities.

In effect, such a view presupposes that one can transfer certain methods, specifically developed for human ways of thinking, into a domain where quite different ways of thought obtain. In point of fact certain operations which the human mind, simply by virtue of its flexibility, finds simple, the machine may handle only with great difficulty, while, conversely, the enormous speed and instantly accessible memory of the machine makes light work of problems which the human mind cannot hope to encompass. From these considerations alone it is apparent that a necessary prerequisite for the economic use of the digital computer is the development of methods sympathetic to its mode of operation. From this point of view the computer may be seen as an agency in the development of new methods of analysis.

Computer Operation

The digital computer may be described as a machine for processing numbers. It is designed so that the process itself may be varied to produce any desired numerical result. The processing is carried out at a great speed (over 2,000 operations per second) while maintaining high standards of accuracy indefinitely. This ability for fast, accurate and consistent working is, ultimately, the only asset of the machine. The problem of economic operation may be posed as a problem of the optimum utilisation of this asset.

In order to show how this optimum is approached, certain aspects of its operation are described below. These have been selected so as to illustrate how the characteristic properties of the machine arise.

In the machine a number is represented by a series of binary digits and may be interpreted, according to the nature of the first digit, either as a real number or as a pair of orders coded into numerical form. Thus a string of numbers may effectively constitute a specially coded list of instruction which the machine will obey. Such a list is called a programme. A programme may be composed of many parts, each with a separate specialised function to perform. These parts of a programme are called "sub-routines."

When a particular type of calculation occurs very frequently a "standard" or "library" sub-routine is written for it. This is preserved on tape and designed so that it may be entered into the machine whenever required. Examples of such calculations are the extraction square roots, logarithms and matrix inversions. Standard sub-routines reduce considerably the labour involved in preparing a programme and they may be employed to considerable advantage.

A great asset of the machine is its ability to automatically repeat a routine any specific number of times, while itself modifying that routine. Each of these times, called a "cycle," may correspond to a particular set of parameters. These parameters can be altered either by putting in new values or by automatically modifying those already in the machine. Thus the machine may be made to "cycle," either taking in new data or processing its own, and giving out the corresponding information.

When the process of repetition is limited to a certain part of the programme, then it is convenient to describe the process as "internal repetition." This process is quite distinct from that in which the complete programme is repeated. The distinction is familiar in all iterative methods, such as in moment distribution—where the process of distributing and carrying over moments is a process of internal repetition, quite different in character from the process of repeating the complete design.

The advantages of internal repetition, where a small piece of the programme may control a large amount of work, are very apparent when the programming costs form a large part of the total cost of calculation. This facility, together with that of using standard sub-routines, gives automatic computation its characteristic properties.

After the overall requirements and strategies of the calculation have been decided, the analytical processes must be reduced to forms involving only arithmetical operations. These may then be translated into a list of machine instructions, to form the programme. This process of programming consumes much human time, and generally makes up the greater part of the cost of machine calculation. As indicated above the programming costs may be reduced by using standard sub-routines and by internal repetition.

Another method of reducing the cost of progamming is to use special routines, such as Autocodes, whereby a very simple list of instructions may be translated, by the machine, into a full working programme. There is, of course, some wastage of machine time during the translating operation, but this wastage may be more than covered by the saving in programming costs. The relative merits, economically, of using Autocodes or full programming will usually depend on the number of runs to be made—the

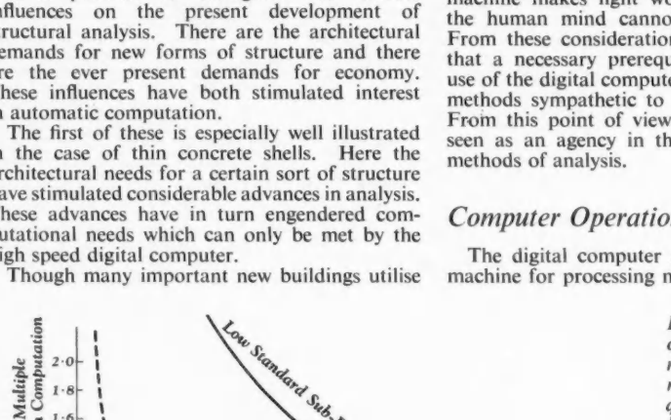


Fig. 1 (Left) Cost of calculation by computer falls rapidly as the number of repetitions increases, and quickly becomes less than human computation.

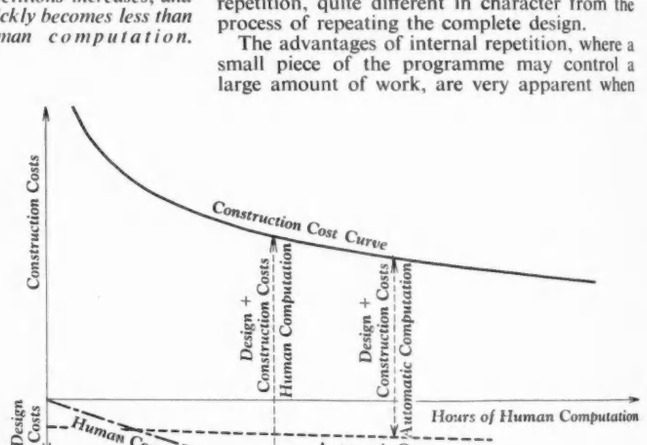


Fig. 2 (Right) The effect of increasing design time on costs of design and construction, indicating how more automatic computation can be economical.

greater number of cycles required, the more likely will full programming prove economically beneficial.

However much costs may be saved on programming, very little can be saved in running cost, since the machine must still run through the computation, whether this is in standard sub-routines and internal repetitions or not.

Recovery of Programming Cost

The initial cost is recovered as the programme is repeated, that is it forms an ever smaller part of the expense of each repetition. Thus the programme has to be used only a few times to recover the low initial cost associated with high sub-routine content or high rate of internal repetition. Higher initial cost can only be recovered by a correspondingly greater number of repetitions.

The results of one investigation are represented in Fig. 1, where the cost of machine computation is compared with the equivalent " hand and brain " costs. It should be emphasised that the diagram, though based on actual programmes, is intended mainly to illustrate the variations that can occur. The investigation showed that, even with a many sub-routines, the calculation had to be repeated at least six times to show any advantages while, under less favourable conditions, as many as 30 repetitions were required. Although these figures are higher than is usual in current design practice, there may nonetheless be considerable advantages in the use of the computer. This may be shown by considering both design and construction cost together.

The problem of design is to produce an efficient structure at a minimum cost, this being accomplished through the agency of structural analysis. In theory at least, some more economical proportions and orientation of structural elements can always be found by a more thorough analysis. In practice, however, there comes a time when the cost of the actual designing outweighs any further savings that might be achieved. This is illustrated in Fig. 2 where the cost of construction and design are plotted against design time, measured in hours of human computation. The cost of automatic computation have been scaled accordingly.

The diagram shows that, although the cost of computer calculation is actually greater than that of hand methods, the overall cost of construction and design may actually be less. The economies are then achieved by a finer design rather than by any saving in design cost.

New Design Methods

Many objections can be raised to such an analysis as the above in the case of conventional methods. Principal among these objections is that the uncertainties of material and construction do not justify such an accurate estimation.

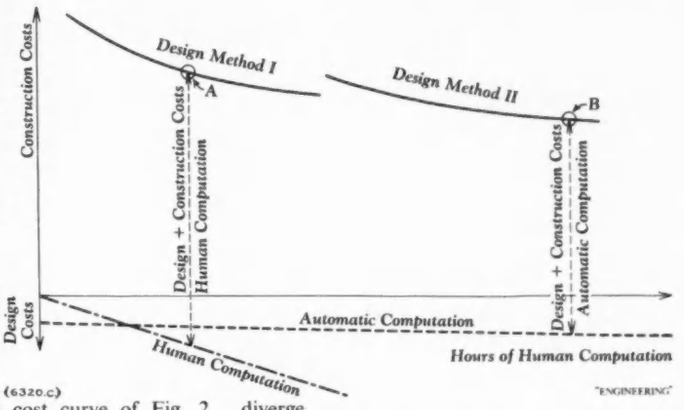


Fig. 3 The introduction of a new design method might involve a great increase in the time required for human computation but requires little extra time if automatic computation is exploited. The new design method may have a great potential for saving construction costs.

To meet this objection it is first necessary to differentiate between the increased refinement of an existing method of design, represented by the continuous construction cost curve of Fig. 2, and the introduction of a new method, which in fact would make the curve discontinuous. The same facilities as make for refinement in one method of design themselves stimulate, and influence, the development of new ones.

Any illustration of this must be largely hypothetical, but the sort of result expected for a framed structure is indicated in Fig. 3, where two design methods are compared. The first of these is intended to represent a conventional elastic design, and the second a minimum weight plastic design. The figure illustrates how the computer may encourage a particular advance in analysis, as without it the jump from A to B in terms of time spent on design would be impossible to justify.

Future Trends

One of the most striking applications of the computer is to the selection of an optimum design. The choice of an optimum generally takes the form of a comparison between numbers, or qualities which may be represented by numbers. Such a choice is very simple for the computer, which may well select an optimum from a much larger group than would otherwise be possible. Thus a minimum cost condition may be incorporated with the structural design procedure, and the machine used throughout the design process.

One of the main obstacles to advance in the field of automatic computation is the cost, initial and operational, of the computer itself. The initial cost is outside the resources of all but the largest groups of consulting engineers. Practice so far has been either to hire both men and machines from a computer centre, or to integrate design work with the research programme of a University. Although satisfactory in the early stages of computer application, the former is necessarily rather expensive and not always convenient, while the latter becomes impractical as the current aims of design and research tend to diverge.

The situation is however a changing one. Digital computers are becoming available in increasing numbers for an ever greater variety of applications. As they become a more accepted part of accounting, industrial organisation and scientific investigation, so their modes of operation will become more familiar, making for greater confidence and enterprise in their utilisation. These developments alone should lead to a considerable reduction in the difficulty and cost of developing new methods, quite apart from any reduction in the cost of machine time occasioned by the greater number of machines available.

It is difficult in this respect to define training, as a mere ability to transform equations into an operational form is not in itself enough. As indicated above the approach must go much deeper, to an ability to formulate the problem in a certain way, and to develop it in a form sympathetic to the means of solution. For this reason progress depends more on the extent to which specialists in the various fields obtain a fundamental understanding of computer techniques, rather than on the training of computer specialists.

For any one structure a number of different mathematical methods can be envisaged, each with its own particular properties. The advent of the digital computer not only changes the choice of method, but greatly increases the number of methods from which the choice can be made. It also makes possible the analysis of structures which could not previously be analysed. A more complete understanding of the way in which structures behave must, in time, influence the shape of these structures. There is here a process of interaction between the engineer and the architect, a process made potentially more fruitful by the introduction of automatic computation.

It is for these reasons that the computer is now viewed as the central instrument in the development of new methods of analysis and in the evolution of new types of structure.

CLEARING HOUSE FOR CIVIL ENGINEERING COMPUTER PROBLEMS

The approach required when writing out a programme for a digital computer was the theme of a one-day symposium sponsored recently by the Cement and Concrete Association. Briefly, for all machines in general use, the computation has to be broken down into a number of discrete steps—the programme of instructions for the machine—each involving not more than two figures which may be either given data for the problem or values derived while making the computation. Although digital computers work in terms of a binary system, the user is never concerned with converting his data to this system, this always being done in auxiliary equipment.

The symposium, entitled " Electronic Digital Computers," was held at the Institution of Civil Engineers on 11 May. Speakers differed somewhat in recommending which problems were suited to a computer, but certainly anything that required lengthy calculation repeated frequently was an economical proposition; the heavier the arithmetic—such as was found in the analysis of a multiple shell roof configuration—the more certain it was that a computer, hired by the hour, would effect a saving in design costs.

For an office tackling only an occasional problem requiring a computer the best approach was to call in an established computer service and let them write out the programme and put the work through the machine. For most design offices it was worthwhile training a member of the staff in computer techniques. It was much easier, it was pointed out, to train an engineer programming than to get a mathematician to appreciate the technical implications of a problem. Active cooperation between the design office and the computer service—with engineering understanding being contributed by the one and computer experience from the other—made for most economic working. Few offices were likely to develop to the extent of needing their own computer and this was hardly necessary as there were computer services, both commercial and within university departments, readily available.

The prime advantages to be secured, apart from eliminating tedious arithmetic and the risks of mistakes, was the freeing of experienced staff to give more time to the design problem and the facility with which a greater number of potential solutions could be tried, so " optimising " the design.

The structures department of the Association were in the position to advise on the use of computers and maintained a register of the services that were available. They were also proposing to compile as full a list as possible of programmes written for all civil engineering problems (not only structural analysis) as a service to the civil engineering profession and industry. The address of the Association is 52 Grosvenor Gardens, London, SW1.

Eggs in Many Baskets

The year 1958 was for most of the companies in the Vickers Group a year of full production. Nevertheless the group's trading profits fell by £1·2 million to £12·3 million. In their report on the year's activities the directors emphasise that " the highly competitive conditions of the previous year have persisted and, in some fields, even intensified. In the export market, conditions of recession in certain industries have had a marked effect on overseas orders." Despite this increased competition, the progress of the group was maintained and in several aspects the year was highly successful.

The two major events of the year for the group's aircraft division were the completion of the first Vanguard propeller-turbine airliner and the award of a contract, in association with the English Electric Company, for the design of a new tactical-strike, reconnaissance aircraft for the Royal Air Force. The company have high hopes of success for the Vanguard based on the fact that it has a relatively high payload and low operational cost. During the year, refinements to the aircraft's design resulted in an increase of 4,000 lb in payload and Vickers consider the Vanguard as " potentially the most profitable airliner ever offered." If sales are as successful as those of the Viscounts (405 had been sold by the end of the year of which 362 had been delivered) and the aircraft is still competitive (30 were ordered during 1958) Vickers will have achieved a remarkable double. The new RAF aircraft, known as the TSR2, will be a high performance machine able to operate from small airfields with rudimentary surfaces and will be capable of performing the roles of the Canberra but with greater versatility. A joint team from both companies is being established at Weybridge to handle the project. Vickers shipbuilding activities have kept at a high volume, although there was a considerable fall off of orders during the year. The order position continues to be satisfactory, however, since the effect of the decline is less immediate in the case of shipyards equipped to build the larger ships. Altogether there were 29 ships on order at the end of the year, including one aircraft carrier, two passenger liners, 10 tankers, 5 cargo liners and a number of naval craft. The report notes that the better steel supply position and an expanding apprenticeship intake have greatly improved the prospects for a more profitable as well as a fuller use of the company's shipbuilding and ship repairing facilities. The highlight of the year at the Barrow shipyard was the start of the construction of HMS Dreadnought, Britain's first nuclear powered submarine. This project, and also the building of a land based prototype set of nuclear submarine machinery at Dounreay, is being handled by a new company in which Vickers have joined forces with Rolls-Royce and Foster Wheeler, known as Rolls-Royce and Associates.

The engineering activities of the group have, on the whole, been very successful. A team of experts visited Russia to discuss the supply of chemical and other heavy plant and considerable business is expected to follow. Among the very large orders secured by the group was one valued at some £5½ million from the London Transport Executive for 532 cars for the Piccadilly tube which will be made by the Metropolitan-Cammell Carriage and Waggon Company. Another large order was secured by the Tractor Company for the supply of 60 Vigor tractors for the British Army. The group's steel-making subsidiary, English Steel Corporation, met with increasing competition in the export field from continental countries short of work, and home demand was also lower than in the previous year.

The group's outlook is cautiously confident. Much reliance is being placed on the steady growth of the technical and numerical strength of the Vickers Group Research Establishment which was constituted as a separate self-contained company in order to simplify its dealings with organisations external to the group. Among the many interesting projects mentioned in the report are the preliminary studies of thermonuclear phenomena, the construction and experimental use of a shock tube aimed at researches in connection with chemical engineering and a number of measuring and control instruments now at an advanced stage of development.

Bigger Boilers Lower Profits

The impact of technical change on the development—and fortunes—of makers of boiler plant and accessories is outlined most clearly in the annual reports of Babcock and Wilcox and Senior Economisers. Both have for many years been vitally concerned with the design and supply of plant for the generation of electricity, and most of it for steam generation in coal or oil burning power stations. The growing emphasis on atomic energy is causing them to reorientate their product policies as they have never had to do in their history. Babcock's are vitally involved in the development of nuclear power stations. In partnership with the English Electric Company and Taylor Woodrow they are engaged in the construction of the Hinkley Point station for the Central Electricity Generating Board and have formulated designs for the installation of atomic power stations abroad. They are also participating in nuclear design for marine propulsion.

The main factor in immediate prospects of both Babcock and Senior Economisers is the curtailment of the CEGB's plans for installing conventional power plant. In addition, rapid technical development has enabled the total steam capacity required for a given electrical output to be reduced substantially and boilers are now built as much larger units. Mr. W. Lionel Fraser, chairman of Babcock and Wilcox, points out that the phenomenal increase in the average size of boilers has reduced the total number of boilers likely to be needed for a year's programme of the CEGB to a quarter of the number ordered a few years ago. " If this pattern endures," he said, " as seems likely at any rate for two or three years, it cannot fail to have adverse repercussions throughout the industry."

This trend has forced the industry to look more and more to export markets as an outlet for its capacity. Dr. D. C. Lycett Green, chairman of Senior Economisers, points out that half the orders received in 1958 were for export. Their turnover was considerably in excess of the total incoming orders and further expansion of exports will be needed if the present rate of output is to be maintained. Babcock and Wilcox have likewise made considerable headway in export markets, which Mr. Fraser stated " have become more vital than ever." Because they had a large volume of orders on hand Senior Economisers were able to work to the full capacity of their manufacturing facilities. Their profits increased by £86,500 to £349,000, but this figure includes a year's profits of Henry Hargreaves whom they acquired in January 1958. Babcock's trading profits were £1·5 million lower at £3·1 million, due to the major world-wide recession experienced in most of the fields of heavy engineering in which the group operate.

Power and Research

Lower profit margins, in which a higher cost of research—particularly in the nuclear field—is a major factor, have resulted in a fall of some £700,000 in the trading profits of C. A. Parsons to £3·1 million. Their new chairman, Mr. F. W. Gardner, who was elected to the chair after the death of Sir Claude Gibb last January, told shareholders in his annual statement that the sales turnover, including contracts completed during the year, was slightly more than for the previous year. The works have operated to full capacity and the orders on hand will keep them fully employed for some time ahead, despite a low volume of orders booked last year. Like Babcock and Wilcox and Senior Economisers, Parsons have found " no increased demand for plant required for power stations in this country which, together with the general increase in the size of individual units, resulted in an appreciable reduction in the number of contracts placed."

Nonetheless, the board of C. A. Parsons have faith in their company's long-term prospects. The major factor in this is the continuous increase of electricity consumption everywhere which enables them to look forward to a continued demand for generating plant which, Mr. Gardner states, " should gain impetus as better facilities for financing capital projects become available." The company's new shops at Heaton are approaching completion and should be in full operation shortly. They will provide the facilities required for the production of the component parts of the turbogenerators of very large size for which they have orders.

Satisfactory headway has been made in the nuclear field. Their associated company, the Nuclear Power Plant Company, are collaborating with AGIP Nucleare of Italy in the construction of a 200 MW atomic power station at Latina, and considerable progress has been made at Bradwell. The construction of the Nuclear Research Centre adjacent to Heaton Works is now complete and this should enable Parsons to develop as a leader in the field.

Electric Competition

Recent under bidding of the major US makers of heavy electrical plant by British and European firms has become a major political issue because it is clear that the future of the American industry is at stake. There is no doubt that firms such as AEI, English Electric, ASEA, Philips, Siemens, AEG and Brown Boveri and Company have made considerable progress against American competition, particularly the German firms. Since 1950, AEG have expanded turnover by 358 per cent, Siemens by 308 per cent, Philips by 224 per cent, and the two English firms, English Electric and AEI by 193 and 163 per cent respectively. The increase in turnover by the two American giants, General Electric and Westinghouse, was less than 100 per cent.

English Electric's new bid for eight turbines for a South Dakota dam project, again the lowest tender, has aroused much indignant comment from American manufacturers. The bid is reported to be near 83 million lower than the lowest American bid. Should English Electric get the order it may well precipitate a crisis. While our need for dollars is great the consequences of a price war between British and American firms in North America could lead to increased competition elsewhere, particularly in those developing countries which are being financed by American capital. It could also lead to the establishment by United States firms of subsidiaries in low labour cost countries, as has happened in shipbuilding. Success in such tenders may not therefore be an ideal solution to our own industry's long-term expansion problems.

Despite their excellent competitive position in world markets however, the British and European firms come nowhere near the American in sheer size. In fact, General Electric (turnover of £1,536 million) and Westinghouse (£713 million) are twice as large as all the major European firms put together. But European firms are catching up; Philips' turnover approaches £300 million; Siemens are next with £241 million, followed by AEI with £149 million. The apparent inability of US firms to compete in world markets, including their own, for heavy machinery may alter the whole competitive position over the next decade. Another important factor is the growth of demand for electrical appliances in other countries, particularly in the continent of Europe.

Anxiety Neurosis

The call for a 40 hour week and worry over some cases of redundancy are salient items of trade union news during a particularly uneasy past fortnight. The unusually large crop of unofficial strikes suggests that union leadership is being sorely tested and the causes of the strikes—demarcation (almost literally) at Birkenhead and at Linthouse, Glasgow, pay grades and holidays at Cowley, and the employment of women in Hinckley—indicate any old reason is good enough for a showdown. The dangers of such a situation are obvious enough; the defeat of Mr. Carron's moderate proposals by the AEU delegates and their choice of what amounts to impossible demands (a 40 hour week and a 15 per cent pay increase) suggests that the militant spirit of the rank and file will make the forthcoming crop of annual meetings of the leading unions very difficult for the leaders.

The underlying cause of most of the current troubles is undoubtedly a feeling that jobs are not nearly so secure as they were a year ago. The statistical improvement in the unemployment situation and the apparent willingness of employers to resume a policy of expansion have had little impact on employees. The latter's mood is markedly sceptical and they are therefore doing all they can to get available work to go further. The AEU led the way when they coupled their demand for higher pay with a claim for a 40 hour week. The same tendency is evident elsewhere, including the printing world. Faced with what they consider is less work to go round, the union's natural reaction is to press for statutory acceptance of a shorter working week and higher rates per hour so that earnings are not diminished.

Redundancy is occurring at Hamble, where Folland Aircraft have warned 600 workers that they will be dismissed over the next two months; in Lancashire 300 miners will be dismissed at Cronton Colliery as a result of reorganisation; on Clydeside, the Ardrossan Dock Company announced that they have no ship on order, building or fitting out (the first yard to be wholly unemployed since the 1930s); in the West Country Bristol Aircraft have informed shop stewards of their redundancy plans over the next three months, which are believed to affect over 1,000 people. There is therefore great activity among the unions on securing safeguards. Mr. Harry Knight, general secretary of the Association of Supervisory Staffs, Executives and Technicians, threatened strikes against employers who refused to take " an intelligent approach to redundancy." Some 2,000 of ASSET's 22,000 members lost their jobs last year. In an article in *The Director*, Mr. L. Wright, chairman of the TUC's production committee, accused employers of being afraid to recognise employees' " right to work " and that this fear—coupled with a wish to palm the responsibility off on to the Welfare State—accounts for the sluggish progress of redundancy schemes. There is a growing demand for compensation agreements, in which the cotton textile unions are prominent.

Unofficial strikes can be expected to increase over the next few months, particularly where employer-employee relations are poor. The strike of the 1,700 boiler makers at Cammell Laird's Birkenhead shipyard is over a dispute as to whom, boilermakers or shipwrights, should mark out plates for cutting. In a leader, *The Times* comments that " absurd though the strike may be, it would be a mistake to regard its causes as trivial. The class of craftsmen to whom new kinds of work is given may mean the differences between employment and unemployment in the future to members of one union or the other. They naturally regard that as a matter of importance to their members." Few would quarrel with this statement.

There is a danger that employers may underestimate the damage that can result from fear. Mr. Heathcote Amory's plea that " a fuller appreciation of the broad social and economic consequence to the nation of decisions taken in a particular industrial sector " requires to be examined in the context of this note. Much of the irrationality of the claims stems from each mans' anxiety over his job.

Psychosomatic Cure

The battle for mental health is being fought with amazing vigour by dedicated men, and it is being fought on many fronts with some considerable success. Slowly the psychiatrist is ceasing to be merely " a doctor for the insane " and is making a major contribution to the cure of the millions of people who suffer from neurotic difficulties. With the help of others—physicians, surgeons and sociologists—he is contributing to the elimination of gastric ulcers, asthma and the many other illnesses which arise or are made worse by psychological unbalance. Moreover, there is an increasing tendency to introduce mental health concepts into public health practice and to seek the advice of psychiatrists on wider social issues such as community development and industrial organisation.

A review of the progress in this field is contained in a special " Mental Health " issue of *World Health*, the magazine of the World Health Organisation. It is a horrifying but fascinating publication. Above all, it shows the immensity of the task which faces the medical profession and more particularly its psychiatric section. The impact of developing schizophrenia on an artist who won fame with his drawings of cats in the early part of this century—Louis Wain, who died a schizophrenic in 1936—is shown by a series of cat paintings which shows remarkable changes in his style as his condition deteriorated. It is not perhaps too much to hope that by the end of the century, insanity also, in all its many and bewildering degrees, will have been banished. The WHO magazine suggests that this might well be so.

Career Show

The first National Education and Careers Exhibition ever held in this country will take place at Olympia early this summer. There will be something in it for everyone—even for the curious taxpayer who wishes to know how money is spent on education.

The education section will cover all aspects of modern education from nursery schools to adult education. In addition to displays showing new teaching techniques, certain industrial undertakings will show their training facilities in a section on training in industry. The careers section is to be organised with the collaboration of over 40 trade and employers' association.

Party visits by parents, students and senior secondary school pupils are being particularly encouraged and special party vouchers are available from the exhibition office for groups of pupils and education students at 1*s* per head. The exhibition takes place between 26 May and 5 June.

Reporting to Employees

The publication of an annual report for employees by the Blaw-Knox Company, Pittsburgh, is a development with an interesting potential. So far most of the large companies in this country as well as in the United States have tried to make their annual reports " readable " by employees, customers and suppliers as well as shareholders. The result is a compromise which in many cases has fallen very much between two stools. Blaw-Knox's *B-K News* is informative on matters which concern the average employee —his remuneration, the company's progress, the company's prospects and plans for the future.

A message from the chairman of the board and president, Mr. W. Cordes Snyder, Jnr., heads the report. He opens by a statement that " throughout last year Blaw-Knox were fighting hard to achieve a good performance in spite of the recession," and comforts those who suffered hardships " from weeks of no pay and weeks of short pay " with " upturn in our demand."

The report is factual, and concentrates on " highlights of the year." It is profusely illustrated by photographs of people rather than products. The emphasis is on the payroll, employee benefits, taxation and reinvestment in the company, for " job security." The report is very short, but those of the 8,900 workpeople who want more detail are invited to apply for a copy of the full annual report.

Commonwealth Training

A move is being made to promote, from this country, the training of engineers and technicians. A distinguished gathering of members of the Government and representatives of Commonwealth countries, employers' organisations, the TUC and educational bodies assembled at Buckingham Palace last week, with the Duke of Edinburgh presiding. He did so in his capacity as president of the City and Guilds Institute. The purpose of this inaugural meeting, which was called by the Duke, was " to examine the possibility of holding Commonwealth technical training and apprenticeship weeks in 1961."

There has long been a need to increase considerably the facilities available in Britain for the training of engineers from Commonwealth countries. Such facilities are being made available in countries which are our main competitors in world trade. It is in fact becoming a major weapon in influencing trade. Quite apart from this, Britain has a special responsibility for the advancement of Commonwealth countries, moral as well as political, and no-one is more keenly aware of this than the Duke, who has spent so much of his time in these countries. Following on the long and commendable efforts of the FBI the Duke may well hold the key to a new and vital advance in this sector.

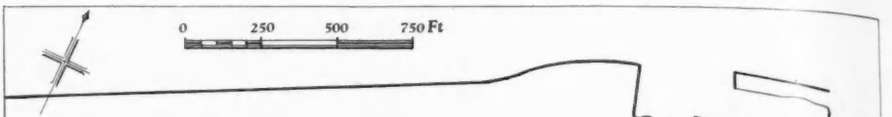
The statement from Buckingham Palace stated that representative committees are being set up to decide upon the details necessary to carry out the scheme, and that the City and Guilds of London Institute have accepted administrative responsibility.

Management Above Mach One

" Managing Aviation Technologies " was the subject of the 47th Wilbur Wright Memorial Lecture given this year by Mr. Charles J. McCarthy, chairman of Chance Vought Aircraft Incorporated. There is a fascinating problem in technology, management and economics to be solved in the aircraft and missile industry.

He points out that the characteristic of the history of flight is the rapid rate of technical change which has taken place. Even a generation ago one man could run a company in the industry as a one-man show. Today, management has become exceedingly difficult. Success in it depends on solving the problem of coordinating efficiently highly specialised scientists and engineers in a highly competitive industry with low financial returns. Individual projects have become so intricate that the military services have transferred management responsibilities to a private weapon system manager. This means in effect running development and production on the basis of a series of consortia which come together for a specific group of schemes while remaining competitors in other schemes. This is growing in America and Mr. McCarthy notices the same sort of pattern emerging in this country with the TSR 2 reconnaissance aircraft between English Electric and Vickers-Armstrongs.

NEW WORKS *in* HULL DOCKS



New port facilities have been commissioned at Hull, comprising a wholly reconstructed Riverside Quay and major improvements along the south side of the adjacent Albert Dock. New works include seven transit sheds, a passenger building, a system of roads and railways, and 18 new Stothert and Pitt wharf cranes.

The former Riverside Quay, fronting on to the River Humber, was an open-piled timber structure 2,500 ft long which was originally built in 1907. Covered shed accommodation ran the full length of the quay and a public right of way along the foreshore had been maintained by an overhead footpath along the roof of the sheds. These structures were wholly destroyed by enemy action in 1941 and the new works have been provided at a total cost of £1¾ million.

A length of 1,065 ft of the old Riverside Quay at the eastern end has been entirely replaced in open-piled reinforced-concrete construction, with a depth of water of 19 ft 6 in at the lowest spring tides and over 40 ft at the highest high water, with three transit sheds each 280 ft long and 82 ft 6 in wide. The sheds have an interior headroom of 20 ft and sliding doors at both front and back are 18 ft 8 in wide and 18 ft 8 in clear height. The right of way has been continued by a footpath over the roof of the two western sheds, and the City Corporation have met the cost involved. There is a quay width of 25 ft at the front of the sheds and a 10 ft wide loading platform at the back served by two lines of railway track. The quay itself has no railway track, so an entirely unobstructed working area is available, and it will be equipped with three 7½ ton and six 3 ton semi-portal level-luffing electric cranes.

A new quay of open-piled reinforced-concrete construction has been provided on the south side of Albert Dock, 1,513 ft long and extending 40 ft further into the dock than formerly in order to give additional working space. Four sheds have been built, each 288 ft long and 82 ft 6 in wide, similar to those on the Riverside Quay but with the sliding doors 16 ft 6 in wide and 18 ft high. The 40 ft width of quay in front of the sheds is provided with two lines of railway track and will be equipped with eight 3 ton and one 10 ton capacity electric cranes. There is also a 10 ft wide loading platform served by two lines of railway track, as in the case of the Riverside Quay.

Considerable attention was given in the design of the works to reduction of maintenance. The new quays are founded on precast prestressed concrete piles made up of three sections, the top and bottom being short solid units and the centre section hollow. The three units are joined and stressed together by high tensile steel bars, extension pieces being added as necessary. Rigidity is imparted to the quay structure by the use of built-in rectangular precast reinforced concrete frames both transversely and longitudinally, and to avoid expensive shuttering over the water the dock is constructed of precast concrete units. Flexible fendering is provided, consisting of hewn Greenheart piles supporting horizontal wallings and rubbing strips which distribute berthing impacts, the whole being cushioned from the dock by rubber cylinders.

Difficulties encountered during pile driving led to the discovery of a buried timber jetty on the line of the new foundations. The timber of this structure was in excellent condition, though probably about 100 years old.

A 30 ft roadway serves both the Riverside Quay and the south side of Albert Dock, with parking areas and access between the sheds to both quays. The railway tracks behind the sheds are flush paved so that the road vehicles may also use the loading platforms. The loading platforms have built-in culverts carrying the fresh water and electricity services, designed to give easy access for maintenance purposes.

At the east end of Riverside Quay extensive accommodation has been provided for passengers entering and leaving the port, including customs and immigration offices. The passenger building is in contemporary style, constructed with reinforced concrete frames and panelled with glass and brick. The interior is also in contemporary style, and an extremely fine mural in the main waiting room depicts the traffic of the Humber from the Viking long ship to the present day. A number of small buildings have also been provided for staff.

The transit sheds are constructed with a reinforced concrete framework panelled with hollow concrete blocks supporting concrete barrel vault roofs with prestressed valley beams. The thickness of the concrete at the crown of the barrels is 3¼ in, and the design is such that no waterproofing membrane has been incorporated.

In order to ensure the high quality concrete essential to the type of construction, strict control methods were adopted with continuous testing in a site laboratory. A consistent ultimate concrete crushing strength of 7,500 to 8,000 lb per sq. in was maintained, and sometimes as much as 9,000 lb per sq. in was obtained. The total quantity of concrete used in the work was 36,000 cu. yd, with 2,300 tons of mild steel and 70,000 ft of high tensile reinforcement.

The whole work was carried out under the general supervision of Mr. G. D. Lloyd, chief docks engineer, Humber Ports. The consulting engineers were Sir Bruce White, Wolfe Barry and Partners of London, and the contractors for the civil engineering work A. Monk and Company Limited, Warrington.

BARKING FLYOVER COMPLETED

The work of re-alignment at Barking on the Eastern Region of British Railways is now nearly finished and both lines over the main flyover have been brought into use. The commissioning of the concrete flyover in an area where there are seven running lines, without serious interference with heavy commuter traffic, completes a major part of one of the most complex railway engineering projects ever attempted anywhere, for more than 700 trains pass through the area daily.

Originally the St. Pancras-Tilbury lines crossed the main Southend lines on the level east of Barking station. The scheme has eliminated the flat crossing by diverting the Tilbury lines to the northwards at the London end of the site and putting them on to the main flyover situated west of the station. In addition, to the east of the station, the west-bound London Transport track has been taken through an underpass beneath the main line so that cross-platform interchange is possible at Barking station. This track then re-crosses the main line west of the station on a second flyover to give normal working of the District lines in and out of London. The elimination of the crossings will cut the traffic delays to give a much improved service.

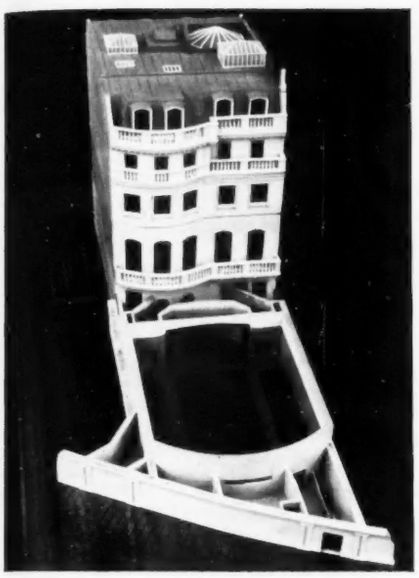
Both the flyovers are of similar construction. The main structure of the Tilbury flyover, shown under construction in the illustration, comprises three "intersection" spans connected and approached by 16 spans each 40 ft long. The London Transport flyover has only one intersection span but the same number of approach spans. Abutments and piers are of mass concrete, while the decks are of composite prestressed construction. The LT underpass, a reinforced concrete invert and side walls, have been fully "tanked." Some strutting has been provided across the top of the deeper open sections and the tracks above are carried on composite prestressed slabs.

The contractors for the civil work are W. and C. French Limited, Buckhurst Hill, Essex. Track work has been carried out by railway staff and the whole of the works are under the supervision of Mr. A. K. Terris, M.I.C.E., chief civil engineer, Eastern Region.

R.Ae. Soc. LECTURE THEATRE

The Royal Aeronautical Society is planning its own lecture theatre. The proposed building, to be added to the Society's existing premises in Hamilton Place, London, will be one of the first projects to be built in conjunction with the Hyde Park Corner reconstruction scheme and will back on to the new Apsley carriageway, to which it will have access.

The cost of the theatre, which will seat 325, is estimated to be £150,000, including furnishings, and the Society has launched an appeal to its 10,600 members and to industry to contribute towards the cost. Three firms have already indicated their willingness to consider making donations amounting to £30,000 and the Society believe that the rest will be forthcoming. The Society—now in its 94th year, for it was founded in 1866—is the oldest aeronautical body in the world with an unbroken record. In 1938 it acquired the house which stands on Crown land and extra land now required will also be leased from the Crown. The Commissioners for the Crown Lands have indicated that they will be prepared to grant a lease for the whole site dated to the year 2004.



Under the Hyde Park Corner reconstruction scheme it has become possible to gain access to land at the back of the Society's house sufficient to permit the construction of the theatre, but access to the site will be permitted only while the road building is in progress. Work will therefore have to start in September, 1959. The form of the new building is indicated in the photograph of the model of the property that has been built by Sir W. G. Armstrong-Whitworth Aircraft Limited.

The Society's premises are built in the French 18th Century manner, and the interior of the building is in the same period. The new theatre is to be built at the rear of the house and will be faced with Portland stone to harmonise with the existing elevations.

Seating for 325 persons is provided, and the theatre, 52 ft by 40 ft wide and air-conditioned, is to be equipped with a stage and facilities for lectures, films and television. It can also be used for receptions and other social functions.

The interior treatment of the building will be carried out in the contemporary manner but has been designed in sympathy with the existing interior decor. The architects for the new work are Ley, Colbeck and Partners, FF.R.I.B.A., Palmerston House, Bishopsgate, London, EC2.

Extensions to Bluff Harbour

New Zealand's most southerly port, at Bluff, is being greatly extended to cope with an expanding meat trade. The project is expected to cost about £3,200,000. The new berthage will comprise two coastal and intercolonial berths, 525 ft long, dredged to 26 ft, and three overseas berths 700 ft long, 35 ft deep. A quay 1,200 ft long is also being built for local shipping. The entrance to the harbour is being enlarged to a width of 350 ft and deepened to 27 ft at low water.

Runcorn Viaduct Strengthened

Strengthening the Runcorn Viaduct is being carried out in preparation for electrification of the Liverpool-Crewe section of the London Midland Region.

Repairs are needed at the cross-girder connections to the main girders and a number of the cross-girders have to be stiffened. The connections are being made good with high tensile bolts and the girders strengthened by the addition of stressed high tensile steel rods. With this work completed the bridge deck is to be waterproofed and, to meet the needs of electrification, the track is to be relaid on sleepers and ballast (replacing the longitudinal timbers that have been used previously).

American Concrete Institute in Mexico

The 12th regional meeting of the American Concrete Institute will be held in Mexico City between 3 and 5 November, 1959. Arrangements are being made through the Mexican Cement and Concrete Association. Emphasis during the technical sessions will be on the design and construction of concrete shell structures; foundations, taking into account compaction or subsidence (Mexico has very poor soil conditions); design against earthquakes; and general considerations of concrete mixes.

Candela's Shells Reversed

Readers of our report last week of Felix Candela's lecture on shell roof experience may have observed that the captions were reversed; the restaurant *is* under the intersecting "saddle" vaults and the bandstand under the fan of hyperbolic paraboloids.

Heavy Duty Roads in Africa

Colonel K. E. Boome and Mr. W. G. Kennedy, chief executive and deputy chief executive of the International Road Federation, have begun a tour of Africa to promote the development of adequate international roads on that continent. Especially attention is to be paid to the possibility of roads to heavy duty standards.

In May, 1957, the Federation arranged a congress in Salisbury to discuss the cost and economic advantages to be had by improving the Cape-Nairobi road; although progress has been made, a major gap still exists in Tanganyika. Mr. Kennedy and others are to present a paper to the International Bank Mission, which is visiting Tanganyika in June to study the economy of the region and advise on priorities for capital development.

Colonel Boome will be studying international road prospects for the Commonwealth and French African territories on the west side of the continent.

Saving Money on Brickwork

The transport of bricks in pack form reduces handling time and costs. It also reduces damage to the bricks. The Building Research Station has developed a system for handling packs of about 50 bricks, steel-strapped, at all stages from the brickworks to bricklayer on site.

Many brickworks have adopted the system and will supply packs of 50 for an extra charge of less than 5 per cent. Details of the system are set out in BRS Digest 121 entitled *Packed Bricks*, published by HMSO at 4*d* per copy.

Research and Road Construction

A full review of recent building into problems connected with road building is contained in a paper presented to the Institution of Civil Engineers on Tuesday, 12 May, and published in the *Proceedings* for April. The authors are Mr. J. M. Fisher (John Laing and Son Limited), Dr. A. R. Lee and Dr. R. S. Millard (both of the Road Research Laboratory). A brief indication is given of research undertaken in respect of soil surveys, earthworks and compaction, pavement design for both concrete and flexible construction, crushed-stone bases, soil stabilisation, bituminous materials, road making machinery and control methods. A bibliography of 59 items completes the paper.

Road Construction Capacity

A much bigger road construction programme could, if the occasion demanded, be undertaken by the civil engineering contracting industry "without the slightest risk of suffering from constructional indigestion." Mr. R. M. Douglas, president of the Federation of Civil Engineering Contractors, said this at the Federation's annual dinner when replying to the toast of the Federation, which had been proposed by Mr. Harold Watkinson, Minister of Transport and Civil Aviation.

In his remarks, Mr. Watkinson had said that he hoped to see more of the "road-over-railway" routes and he also commented favourably on the four-lane double decker road carried on central pillars erected along the central reservation of existing roads.

The new chairman of the Federation is Mr. J. Maurice Laing.

Civil Engineering Computer Programmes

The Cement and Concrete Association, 52 Grosvenor Gardens, London, SW1, are establishing a clearing house for digital computer programmes applicable to all branches of civil engineering—embankment and dam stability, hydraulics and road alignment, as well as all aspects of structural design. This should assist in saving duplication of effort in writing out programmes, especially where lengthy analysis is involved.

Some advantages obtained by the use of digital computers are discussed in a special article on page 666.

Accidents in the Cement Industry

Accidents occurring in the Portland cement industry were down to 254 during 1958, a reduction of over 23 per cent on the previous year. Since 1950 when the Cement Makers' Federation appointed an accident prevention advisory committee, there has been a steady fall in the annual number of accidents from 550 to less than half that figure. The promotion of accident consciousness has, the committee believe, become increasingly recognised as an essential factor in running a works.

Among all the divisions of types of accidents only one—cement or lime dust in the eyes—showed an increase over last year. Since there are numerous and excellent eye protectors available, the committee are going to pay special attention to this particular problem.

PASSING ON RESEARCH RESULTS

From time to time, members of both Houses of Parliament have expressed their concern that the latest research results should be made known quickly throughout all levels of industry, and have shown particular anxiety respecting the smaller firms with little or no scientific staff to keep them abreast of new developments.

This problem was raised again in the Commons last week, when Mr. Leslie Thomas (Conservative) drew the attention of the Parliamentary Secretary to the Ministry of Works to the need for the Department of Scientific and Industrial Research to take steps for improving the communication of up-to-date research results to the smaller firms in industry.

Speaking as the representative of the Lord President of the Council, Mr. Harmar Nicholls said that the DSIR was helping active local organisations to build up regional technical information centres based on Birmingham, Bristol, Cardiff, Manchester and Newcastle upon Tyne. The staffs of these centres would put firms in touch with sources of information.

When Mr. Thomas asked how these centres would approach small firms in their localities so that the firms might take advantage of the services which were to be provided, Mr. Nicholls replied that contacts were made by actual visits from the research centres and by normal press reports and brochures He did not know whether he could have published the addresses of the centres, but he would look into the matter. He told Mr. H. Hynd (Labour), who wanted a " reasonable charge " to be made for providing firms with the results of research, that, generally speaking, financial contributions were made by the industries concerned Contributions also came from various organisations supporting those industries.

PSYCHOLOGY IN INDUSTRY

It was suggested by Mr. G. A. N. Hirst (Conservative) that the DSIR should issue industrial versions of research reports on social and psychological problems in industry. He asked whether this work was not, in fact, financed from conditional aid funds provided by United States economic aid, and whether the work would come to an end when the granting of those funds ceased.

Mr. Harmar Nicholls said that, from the research reports on social and psychological projects in industry, the Department, with the agreement of the Medical Research Council, had selected twelve projects as being suitable for presentation in a short and popular form. Three of them had already been published by HM Stationery Office and other issues were in preparation. The costs of publishing the popular versions of the results of this research did not all come out of conditional aid. The Department intended to go on with the twelve projects in any case, quite apart from the conditional aid funds.

SCOTTISH TECHNICAL EDUCATION

A request was made to the Secretary of State for Scotland by Mr. G. M. Thomson (Labour) for information regarding the new consultative body being set up in Scotland on vocational further education. In reply, Mr. John Maclay said that the new organisation would be known as the Scottish Technical Education Consultative Council. Its terms of reference would be " To secure the widest possible measure of consultation on vocational further education in Scotland between employers, employees and those responsible for its provision, and to advise on, and generally to promote, the development of such education."

The chairman of the council would be Mr. Edmund P. Hudson, managing director of Scottish Agricultural Industries Limited. Sir David S. Anderson, Ph.D., F.R.S.E., M.I.Mech.E., Director of the Royal College of Science and Technology, Glasgow, would be the vice-chairman. Other members of the council would include Mr. Patrick Mitchell, governor of Robert Gordon's Technical College, Aberdeen, representing the governing bodies of central institutions; and Dr. H. B. Nisbet, F.R.S.E., Principal of the Heriot-Watt College, Edinburgh, and Mr. S. Arrell, Principal of Esk Valley College, representing the principals of further education establishments. In addition, representatives of the British Employers' Confederation, the Council of Scottish Chambers of Commerce, the Federation of British Industries, the Scottish Trades Union Congress, and other organisations, would serve on the new council.

GOING TO YALE UNIVERSITY

Traffic engineering is bound to play an increasingly important part in Britain's general traffic planning, if the best possible use is to be made of her existing road system and of additions to it. Therefore, said Mr. Harold Watkinson, Minister of Transport and Civil Aviation, he had approved of two officers of his department going to Yale University in the coming autumn to take the university's post-graduate course in traffic engineering.

He told Mr. G. R. Strauss (Labour) that he regarded it as essential that his department should have at its disposal up-to-date knowledge of the work being done and of the techniques being developed and employed in the United States, where traffic engineering had been studied and employed more intensively than in this country. He was glad to state that the London County Council, the Birmingham City Council, and the firm of Wilson, Kirkpatrick and Partners, had each applied to enter an engineer from their staff for this course, which lasted for eight months.

DISPOSING OF GAS LIQUOR

Attention was drawn by Mrs. H. Slater (Labour-Cooperative) to the gas liquor which was being poured into the river in the Birmingham area. She referred to the report of the Trent River Board for 1958, which, she said, made special reference to the acute position that had arisen from this action, and affirmed that too much of the liquor was still being poured into the river in the Stoke area.

In reply, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Housing and Local Government, said that much research and experimental work was being carried out in this connection by the Gas Council and the area gas boards, in collaboration with other bodies. Progress was being made and this was reported in the technical journals. The problem was a complex one, however, and quick results could not be expected. Since the nationalisation of the industry, gas production had been centralised in bigger units. That action had aggravated the problem, which was a very real one in the Potteries. Research was proceeding at an increasing tempo and his ministry would do everything it could.

OVERSEAS INVESTMENT INQUIRY

Mr. D. Heathcoat Amory, the Chancellor of the Exchequer, said that in 1956 the Prime Minister, who was at that time Chancellor of the Exchequer, had told the House of certain improvements he considered desirable in economic statistics. He had said that it was in the interests of everyone that this information should be available and that the earlier the Government received it the more timely could be their action to keep the country's economy on an even course.

One of the subjects mentioned on that occasion was statistics relating to the balance of payments, including especially capital transactions. Some improvements had been made, but it was now clear, Mr. Amory told Mr. G. A. N. Hirst (Conservative), that direct approach to industry was necessary if better and more up-to-date information was to be obtained respecting the interest, profits, dividends and capital transactions connected with investments abroad by British companies, and similar investments by oversea companies in this country. Also, the Government needed better estimates of the important contribution which the British insurance industry made to this country's balance of payments.

Direct inquiries were therefore to be instituted by the Government into these two aspects. They would be conducted in the main by the Statistical Division of the Board of Trade and would be completely confidential as to the affairs of individual concerns. If full cooperation were given by those approached, a valuable addition would be secured to the statistics available for studying the country's economy.

NUCLEAR SHIPPING IS URGENT

Interest in the prospects of nuclear propulsion for ships was shown by both Mr. Roy Mason (Labour) and Dame Irene Ward (Conservative). The former asked when a decision would be made about building such a ship as a pilot project to test the efficiency, economics and safety of nuclear marine propulsion units. Dame Irene referred to the successful development of nuclear propulsion, as evidenced by British firms at the recent exhibition arranged by the Admiralty, and wanted a Government-sponsored prototype to be at sea as soon as possible in the interests of British trade.

Mr. T. G. D. Galbraith, the Civil Lord of the Admiralty, informed them that, following the presentation of alternative reactor systems arranged by the Admiralty early this month, the next step would be a technical appraisal of the respective merits of the individual systems. This examination was in hand as a matter of urgency, but, until it was completed, a decision to build the first British ship could not be taken. The Government fully recognised the importance of doing everything they could to introduce nuclear propulsion in merchant ships.

Diesel versus Steam Locomotives

Replying to Mr. David Griffiths (Labour), who wanted a comparison of the cost of maintaining a diesel engine and a steam engine of comparable power, Mr. G. R. H. Nugent, one of the Joint Parliamentary Secretaries to the Ministry of Transport, said he had received estimates from the British Transport Commission. From the Commission's limited experience, so far, of main-line diesel operation, they considered that the cost per engine mile of a diesel locomotive would be likely to be at least 20 per cent less than that of a steam locomotive of comparable power.

Railway Closure Proposals

Information about the number of railway closure proposals submitted to the Transport Users' Consultative Committees was asked for by Sir Archer Baldwin (Conservative). He also wanted the Minister of Transport to say in how many cases the committees had given a decision against the British Transport Commission's proposals. Mr. Harold Watkinson stated that 246 closure proposals had been submitted to these committees during 1957 and 1958. Of that number, 12 had been rejected and a further 13 had been modified at the request of the committees.

More Information About the Welsh

A request was made by Mr. Peter Thomas (Conservative) to Mr. Henry Brooke for details of when the annual *Digest of Welsh Statistics* was to be published. Replying in his capacity as Minister for Welsh Affairs, Mr. Brooke stated that the *Digest* for 1958 had been published on 14 May. Formerly, the *Digest* had appeared at about the same time as the *Report on Developments and Government Action in Wales and Monmouthshire*. The *Report* was now published much sooner after the end of the review period and before full statistics for the period were available. In future, therefore, there was bound to be an interval of time between the publication of the two documents, but the *Digest* would contain a more comprehensive and informative statistical record than hitherto.

Nuclear Ships in Context

SEVEN nuclear reactor systems designed for the propulsion of surface ships have been put forward by private companies at the Admiralty's request; an eighth has been described by the United Kingdom Atomic Energy Authority as a basis for comparison. Both the Admiralty and the British Shipbuilding Research Association have been concerned with the official study, which makes use of the Advanced Gas Cooled Reactor now building at Windscale. Details of the seven company proposals were published in Atomic Review last week, together with an analysis of the way in which the AGR might be adapted for marine propulsion. This week further details of the ship reactor systems are noted, together with some considerations in the design of marine nuclear plants, and other news of nuclear ship development. A summary of marine nuclear activities throughout the world appeared in Atomic Review last 24 April, when a full list of references to previous notes and articles on the subject was also published.

Mitchell—Fairfield—Combustion BWR Plant

A nuclear propulsion system based on a closed-cycle boiling-water reactor was put forward at the recent Admiralty conference (see Atomic Review last week) by the consortium comprising Mitchell Engineering Limited of London, the Fairfield Shipbuilding and Engineering Company Limited of Glasgow and Combustion Engineering Incorporated of New York. The plant, which is designed for a large ship of 50,000 s.h.p., would produce steam for two sets of 25,000 s.h.p. engines and for all power plant and ship auxiliaries. Each of the four heat-exchanging loops would comprise a primary separator, a condenser heat exchanger, a subcooler, a circulating pump and associated pipework and valves. The basic flow diagram for the system and the arrangement of the reactor are shown in Fig. 1.

Advantages claimed are: (1) BWR enjoys advantages of light water moderation plus (*a*) lower steam pressure for given operating temperature, (*b*) additional inherent control by negative reactivity coefficient of steam voids, and (*c*) better heat transfer conditions in condensing heat exchangers; (2) uranium dioxide fuel compatible with water; (3) closed cycle system limits radioactive fluids to reactor room; (4) primary water level in primary separators external to the reactor vessel reduces effect of ships' motion; (5) four loop heat exchanger system gives flexibility and allows partial operation in case of heat exchanger failures, for example, 80 per cent full power with one loop isolated; (6) forced circulation gives positive operation at higher powers; (7) reactor is capable of manoeuvring performance comparable with conventional plant; (8) main steam reheating system located between high and low pressure turbines, eliminating erosion problems at the low-pressure exhaust blading and increasing thermal cycle efficiency; (9) equipment for waste disposal—discharge of radioactive material unnecessary during normal operation; and (10) xenon override provided.

Data for Mitchell-Fairfield-Combustion Ship Propulsion Plant

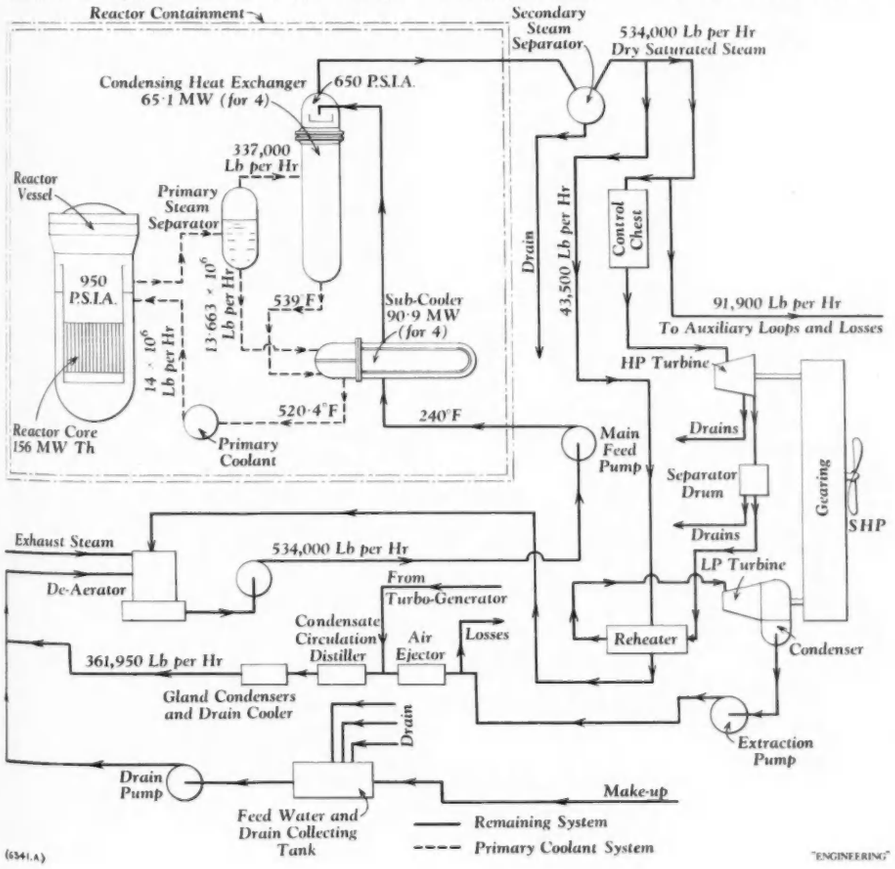
Reactor rating	175 MW (heat)
Reactor output at full power	156 MW h(eat)
Primary coolant pressure	950 lb per sq. in
sat. temp	538·4° F, (281·4° C)
flow rate	14,000,000 lb per hour
Primary steam production	337,000 lb per hour

(Primary coolant would enter the reactor vessel at 520·4° F, (271·3° C,) and travel upwards through the core absorbing 90·9 MW of sensible heat in the lower part of the core and 65·1 MW of latent heat in the upper part of the core. If the ratio of steam velocity to liquid velocity is 1·2 to 1·0, there would be an average of 7·3 per cent steam voids in the core. The primary condensate from the condenser heat exchangers would mix with the primary water at the subcooler outlet and be returned to the reactor vessel by means of the primary circulating pumps, traversing the annular space between the reactor vessel shell and the core shrouding and passing through the diffuser basket to the base of the core.)

Reactor core: active volume 287 cu. ft
Effective length of core 94 in; effective core radius 41 in
No. of fuel assemblies 216; Fuel rods per assembly 56

Fig. 1 Flow diagram (below) and arrangement of closed-cycle boiling-water reactor (right) for the marine propulsion plant proposed by the Mitchell-Fairfield-Combustion Engineering group.

1. Reactor vessel closure
2. Upper motor deck
3. Reactor vessel support ring brackets
4. Dowel brackets
5. Motor drives
6. Refuelling vessel closure
7. Upper motor deck
8. Lower motor deck
9. Actuating rods
10. Shielding deck
11. Superstructure
12. Reactor vessel closure
13. Biological shielding
14. Vessel support brackets
15. Reactor vessel
16. Control rod
17. Fuel capsules
18. Fuel elements
19. Anti-sway brackets
20. Core plate
21. Diffuser basket
22. Motor platform shielding
23. Lead shielding
24. Steel
25. 20 in nozzle
26. 18 in nozzle
27. Lead domed securing bolts



(6341.A) "ENGINEERING"

Fuel cylindrical uranium dioxide pellets
Initial enrichment 2·55 per cent uranium 235

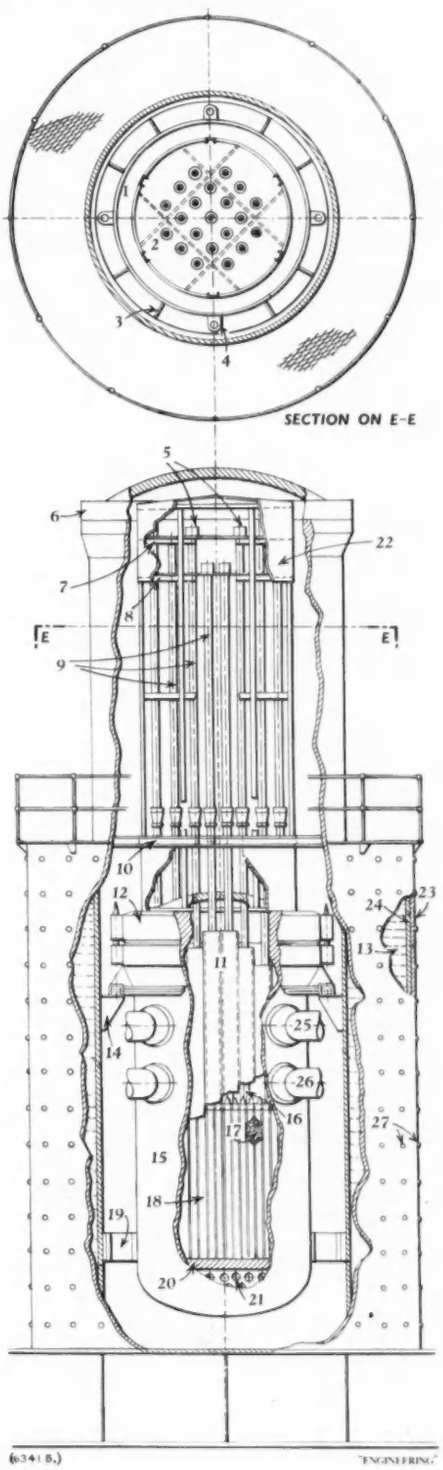
Canning: 0·366 in diameter stainless steel, 0·015 in thick, 8 ft long bonded to fuel by helium gas and sealed at both ends

Fuel elements:
(*a*) UO_2 pellets all of 2·55 per cent enrichment
(*b*) half UO_2 pellets of 2·55 per cent enrichment, half natural uranium, placed at each corner of fuel assemblies to control hot spots caused by the high flux in the water channels outside the fuel boxes and to reduce axial neutron flux variation

Fuel rating	8·75 kW per kg of U
Burnup guaranteed	11,023 MWD per tonne
Power density, average core	19 kW per litre
Weight of uranium dioxide fuel	43,618 lb

Operation at full power for about 3½ years without refuelling; to give uniform burnup shuffling of fuel elements would be carried out at 12 or 15 month intervals.

Control: 21 cruciform rods of three different compositions and 15 in poison length
Centre rod: entirely hafnium
Four rods surrounding centre: 60 per cent hafnium, remainder boron steel
Scram rods: 16 outer rods entirely boron steel



(6341.B.) "ENGINEERING"

Reactor pressure vessel: vertical cylinder of carbon steel 4 in thick clad with stainless steel 0·2 in thick

Inside diameter	9 ft
Length over heads	23 ft 10 in
Weight	90 tons
Moisture outlets: nominal bore	20 in
Inlet nozzles: nominal bore	18 in
Secondary fluid: pressure	650 lb per sq. in a
sat. temp	496° F
flow rate	534,000 lb per hour
feed water temp	240° F
Turbine steam rate	7·972 lb per hour per s.h.p.
Reheat steam rate	0·87 lb per hour per s.h.p.
Vacuum	28 in Hg
Sea temperature	75° F

Primary biological shield: 3 ft 6 in wide annular borated water tank extending throughout height of reactor vessel. Additional shielding in a radial direction from core several feet higher than vessel, comprising 4½ in stainless steel, 7 in light water, 15 in mild steel, 4 in stainless steel thermal insulation, 19 in air gap and 1 in lead (not disposed strictly in this sequence); supplemented by 2 ft 6 in thickness of light water in quench tanks

Secondary shielding: containment vessel to which is applied lead of varying thickness from 3 in to 6½ in. Local shielding round particularly active equipment

Containment compartment: houses reactor, four primary circulating loops and associated equipment; admission prohibited during operation

Shape: ellipsoidally headed flat bottomed cylinder

Inside diameter	46 ft
Overall height	50 ft 2 in
Design max. press contained	130·1 lb. per sq. in g
Anticipated max. press.	104 lb. per sq. in g

Function: (1) containment of radioactive fluids in the event of a maximum credible accident; (2) containment of radioactive fluids in the course of normal operation; (3) support for secondary shielding; and (4) additional protection for core in case of hull damage.

Safety features: (1) negative void coefficient of reactivity and negative temperature coefficient of reactivity, providing self-limiting power characteristics; (2) control and scram rods; (3) pressure relief system; (4) borate injection shutdown system if control and scram rods fail to take effect; (5) isolating valves localise spread of reactivity in accident conditions; (6) emergency decay heat system; (7) emergency reactor spray to prevent meltdown; (8) closed cycle system confines radioactive fluid to reactor room; (9) containment compartment; (10) startup interlocks prevent cold startup accident; and (11) containment compartment spray.

Steam-Cooled Heavy-Water Moderated Reactors

In view of the steam-cooled heavy-water moderated reactor plant put forward by Vickers Nuclear Engineering Limited at the Admiralty conference and described in Atomic Review last week, reference is made to another project based on a similar system. The Vickers system employs a thermocompressor in the primary circuit to provide self-circulation of the steam, and, since in addition control is afforded by raising and lowering the level of the heavy-water moderator, there are virtually no moving parts in the core. A concept feasibility study has also been reported for a 200 MW (electricity) 530 MW (heat) reactor. Steam at 2,200 lb per sq. in enters the reactor; forty per cent of the steam is heated in the peripheral region to 1,050° F (566° C) and flows to the turbine. Sixty per cent is heated to 950° F (510° C) and vaporises the water from the condensers. A low-pressure aluminium tank containing heavy-water moderator is mounted horizontally in graphite. Horizontal Zircaloy pressure tubes for the stainless steel-clad uranium dioxide fuel rods and steam coolant go through the aluminium tank. Thermal insulation between pressure tubes and moderator must be provided. It is concluded on the basis of energy costs and other characteristics that the development work required to achieve this type of reactor is worthwhile. (East Central Nuclear Group and Babcock and Wilcox Company, Atomic Energy Division, Lynchburg, Va. *Nuclear Science Abstracts.*)

Hawker-Siddeley OMR Fuel

The ship-propulsion project proposed by the Hawker Siddeley Nuclear Power Company employs an organic moderated reactor (see Atomic Review last week). A fuel element bundle for this reactor is illustrated in Fig. 2, showing the nineteen fuel rods and the barrier tube separating (into zones) the terphenyl coolant from the terphenyl moderator.

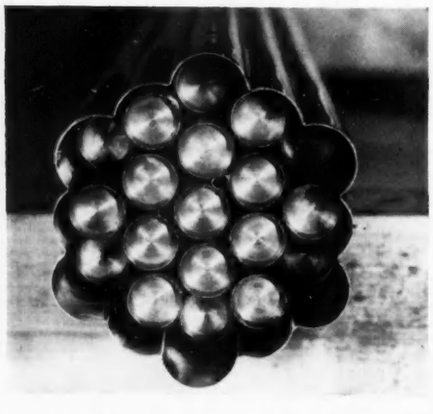


Fig. 2 Fuel element bundle for the Hawker Siddeley organic-moderated marine reactor.

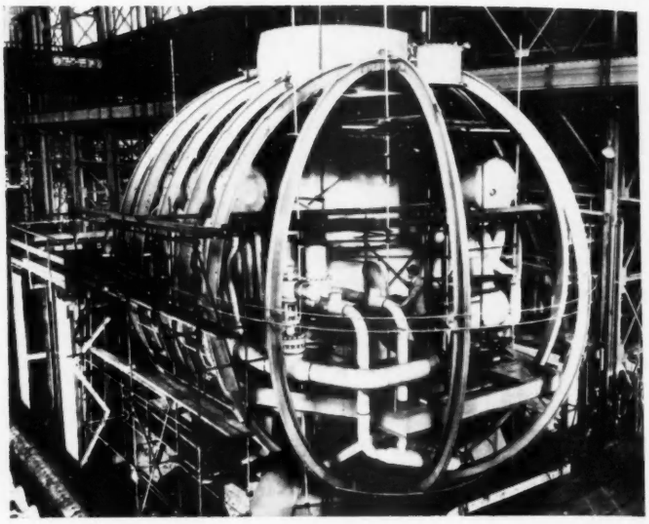
Access to AEI-JT BWR Marine Plant

The AEI-John Thompson Nuclear Energy Company, whose direct-cycle boiling-water reactor marine propulsion system was described in Atomic Review last week, prescribe the number of hours access permissible per week in various areas of their proposed plant: inside containment vessel 1·5; reactor room outside containments vessel 15; engine room 5; control room 100; gear room 100; 2 ft from turbines 1; 2 ft from condenser 0·5; 3 ft from feed system 1. These figures are based on 100 mrem per week.

Savannah Launching

The Nuclear Ship Savannah is to be named by Mrs. Dwight D. Eisenhower when it is launched on 21 July, 1959, at the New York Shipbuilding Corporation's yard at Camden, New Jersey. Fig. 3 shows a full scale model of the reactor and associated plant, and a view of the ship under construction appears in Fig. 4. President Eisenhower, in implementing the legislation for the ship, directed the USAEC and the Department of Commerce, in October, 1956, to proceed as rapidly as possible with the design and construction of the ship.

Fig. 3 A full-scale wooden model of the pressurised-water reactor and associated plant for the N.S. Savannah.



Savannah Schedule

The proposed schedule of operation of the N.S. Savannah, after her delivery early in 1960, is in three phases: phase 1, initial trials and tests—six months to a year; phase 2, national and international operation in modified commercial service for operational evaluation purposes; phase 3, commercial operation in passenger-cargo services. The engineering crew of the ship is receiving instruction in reactor theory, engineering and operation at the US Maritime Reactor School in Lynchburg, Va. These trainees will also receive on-the-job training at Atomic Energy Commission facilities. After review and examination those who successfully complete the course of training will comprise the first engineering crew of the N.S. Savannah. The N.S. Savannah will be a combination passenger-cargo vessel, 595½ ft long, with 78 ft beam. It will be capable of carrying more than 60 passengers, a crew of about 100 and 9,500 tons of cargo at a speed of 20¼ knots. The reactor is designed to operate for over three years on its initial fuel loading. It is of the pressurised water type and is being built under an Atomic Energy Commission contract by Babcock and Wilcox. The British Babcock and Wilcox Company, who have long collaborated technically with the American concern, are one of the firms that recently submitted designs at the invitation of the Civil Lord's Committee (see Atomic Review last week). The ship was designed by George G. Sharp Incorporated. Total cost of the ship and reactor will be about $40,000,000.

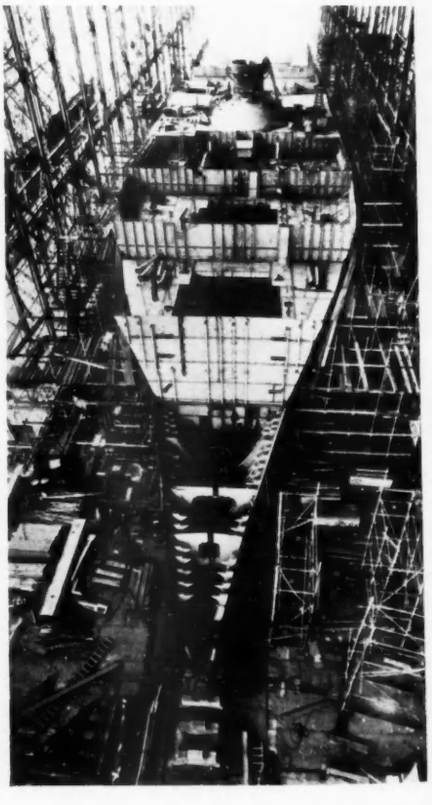


Fig. 4 View of N.S. Savannah in the ship building yard at Camden, New Jersey.

Hazard Analysis

Nuclear plant accidents fall into two major categories: (1) reactivity accidents resulting from the introduction of more excess reactivity than normally required for increases in power, and (2) mechanical accidents due to malfunctioning or failure of plant.

Much work has been accomplished in the development of the merchant ship reactor (the pressurised water reactor in the Savannah) to define precisely possible accidents in both categories given above, including the maximum credible accident. The design of the containment vessel is based on the instantaneous release and expansion of the entire contents of the primary system which develops the maximum conceivable vessel pressure of 173 lb per sq. in abs. This assumes a rupture of the primary system but is quite conservative due to the unlikelihood of a large rupture. Failures are apt to start as small leaks which can be detected in time to take appropriate action. In this instance, in considering the maximum credible accident the following sequence of events is accepted as possible but highly unlikely to occur.

(1) The maximum leak which can be accepted as credible (because of the conservative design) is a longitudinal rupture in one of the 12⅛ in i.d. pipes in the primary system. The leak is assumed to be equal to the pipe cross section.

(2) As a result, primary system pressure drops to saturation at approximately 700 lb per sq. in.

(3) Pressure drop will scram the reactor; the rods are driven in by the positive hydraulic force available in the drive system.

(4) Approximately 25 per cent of the primary system will now contain steam—the developed negative void coefficient in core due to this steam will assist in reducing the power output of the reactor.

(5) Twenty per cent of the primary system flashing to steam will bring the system within containment vessel to equilibrium but the pressure vessel water level will be reduced below the core so that the core is exposed to steam only.

(6) Generation of decay heat within the fuel elements increases temperature in hottest portion of core. At 1,600° F it is assumed that the cladding will fail. Released gaseous fission products are assumed to be uniformly dispersed immediately throughout the containment vessel. Since the melting point of the stainless steel cladding (approximately 2,550° F) is considerably below the UO_2 pellet melting point (over 5,000° F) the fuel element temperature will increase until the cladding melts and UO_2 pellet particles will fall into the lower part of the reactor vessel. (7) The continuing decay of fission products within the pellet particles continues to generate heat which is transmitted to the reactor internals, including the lower portion of the reactor vessel. The heat loss through the pressure vessel walls is a function of the insulation on the vessel exterior. Assuming no insulation, the reactor vessel will remain intact and will hold the melted core. (Godwin and Hess.)

Maximum Radiation Levels

The maximum radiation levels permitted in various shipboard spaces of the Savannah are indicated in the table below. (Considerations of Safety in Nuclear Ships, R. P. Godwin and K. W. Hess, USAEC, Joint Panel on Nuclear Marine Propulsion, UK.)

Maximum Radiation Levels in Various Shipboard Spaces Aboard the Savannah

Location	Operating conditions	Accessibility	Design dose rate
Passenger areas	Normal power operation	Unlimited	500 mrem per yr
Crew spaces	Normal power operation	Passengers not permitted access	5 rem per yr
Areas outside secondary shield wall (crew working spaces)	Normal power operation	Limited	100 mrem per wk
Inside containment	Reactor operating	None permitted	Excessive
Inside containment	Reactor shut-down for half an hour or longer	Limited	200 mrem per hr
Reactor areas occupied during fuel transfer operations	Reactor shut-down for ten days or longer	Limited	Controlled by Radiological Health Officer
Cargo holds	1/5 maximum power	Unlimited	500 mrem per yr
Adjacent to demineralisers for disconnecting by crew	Reactor shut-down for several hours	Limited	200 mrem per hr

Safety in Nuclear Ships: Bulletin

The American Society of Naval Architects and Marine Engineers has announced publication of a technical and research bulleting (No. 3-6, price $1·00) entitled *Safety Considerations Affecting the Design and Installation of Water-Cooled and Water-Moderated Reactors on Merchant Ships*. (Details from the American Bureau of Shipping at 45 Broad Street, New York 4, N.Y.)

Navy's Nuclear Powered Ships and Submarines

Within about 10 years, it is reported, the Navy hopes to have a fleet of 8 or 9 nuclear powered submarines costing about £135 million. One or two surface ships with nuclear propulsion systems are also likely to be built for the Navy before any nuclear merchant ships are built.

Vickers Building Submarine Prototype

Vickers-Armstrongs (Engineers) Limited are main contractors for the submarine land-based prototype now building at Dounreay. Sketches of the prototype hull in the building are shown in Fig. 5. The prototype consists of that section of the submarine hull containing the nuclear propulsion machinery and control compartments, and embodies all machinery details including charge-discharge apparatus. Services such as waste-disposal plant permit continuous operation at full power, and laboratories are provided, together with lecture theatres, for the training of submarine crews. Vickers-Armstrongs (Engineers) Limited, are working in conjunction with Rolls-Royce Limited and Foster Wheeler Limited in the design of machinery for the reactor room. The hull section and its support and the seawater shield tank are being designed and constructed by Vickers-Armstrongs (Shipbuilders) Limited.

Dreadnought Building

Documents for the Dreadnought propulsion machinery, which is the responsibility of the same group of firms, arrived in Britain from America last month, but the process of transferring the £10 million worth of plant into the hull which Vickers-Armstrongs (Shipbuilders) will build at Barrow-in-Furness is expected to take 2 years. The group have a technical agreement with the Westinghouse Electric Corporations, who were responsible for the propulsion machinery in Nautilus, Skipjack and other United States submarines.

Neptune Instrumentation

The reactor NEPTUNE is a zero-energy water-moderated reactor designed by Rolls-Royce and installed at the Atomic Energy Research Establishment to study the design of a power reactor for the British submarine prototype machinery at Dounreay. The absorber control for NEPTUNE was designed and built by Rolls-Royce and withdraws the absorber sheets from the reactor core and controls the rate of fall at the maximum, at the same time preventing damage to the sheets. The control has been designed on the fail-safe principle. The Herriott probe is a development of an instrument designed by the AERE for use on the reactor DIMPLE and is used in the reactor NEPTUNE. It indicates changes in the water level to an accuracy of $\pm$ 0·1 mm.

Fuel for French Submarine

An agreement to provide France with enriched uranium for her atomic submarine now under construction has been signed by the United States Government. It provides for sale to France during the next 10 years of up to 440 kg (970 lb) of enriched uranium, 300 kg enriched to 90 per cent uranium 235 and the rest to 20 per cent. Intended originally to use natural uranium, the submarine, whose keel was laid at Cherbourg early last year, has been redesigned in the light of recent more favourable terms for the supply of enriched fuel.

Italian Naval Reactor Centre

The Italian Navy is reported to be negotiating with the American Machine and Foundry Company for a 3 MW swimming pool research reactor to be installed at the Naval Centre for the Military Application of Nuclear Energy, CAMEN, near Leghorn.

Nucleate Boiling Naval Reactor

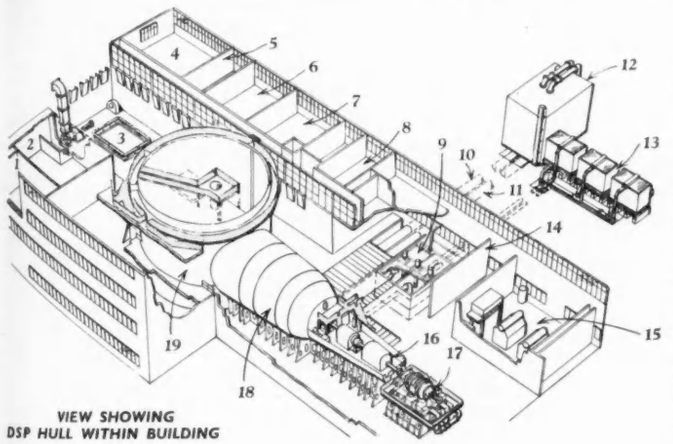
A natural-circulation pressurised-water reactor with nucleate boiling is understood to be under development at the Bettis Laboratory of the Westinghouse Electric Corporation for naval use.

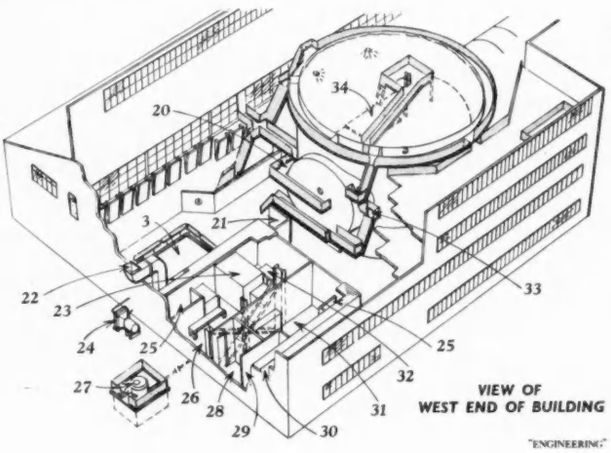
Submarine Projects

Various companies in this country and abroad have considered the design of nuclear submarine cargo vessels. They include Mitchell Engineering and Fiat-Ansaldo of Italy (see references AR 24 April). Mitsubishi's Kobe shipyard in Japan has proposed a submarine tanker of the general layout shown in Fig. 6. The firm state (Geneva Conference P1320) that problems remaining to be solved include: the perfection of nautical instruments for underwater navigation, counter radioactivity measures in the totally enclosed hull, and the operation of the reactor plant cooling system during underwater navigation. The 590 ft 48,200 ton (displacement) tanker can carry 30,000 tons of cargo oil at 22 knots submerged cruising speed and is powered by a pressurised water reactor. The safe operating depth is 328 ft.

Data for Mitsubishi's PWR Powered Cargo Submarine

Power	44,000 s.h.p.
Reactor output	150 MW (heat)
Fuel charge	7,270 kg U
Fuel	Pelletised UO_2
Enrichment	1·7 per cent
Cladding	Zircaloy
No. of fuel elements	88
Control: 17 cruciform cadmium silver rods	
Burnup	9,200 MWD per tonne
Refuelling period: 10,000 hours on full load (2 years operation)	
Primary coolant inlet temp. 280° C; outlet temp. 260° C	
Heat exchangers: 2 vertical shell and tube steam generators	
Steam conditions: 566 lb per sq. in, 482° F	
Turbines: 2 cross compound each delivering 22,000 s.h.p.	





1. Clean component assembly room
2. Decontamination room
3. Pond for storage and manipulation of active fuel elements
4. Chemical laboratory
5. Equipment store
6. Instrument laboratory
7. Electronic laboratory
8. Monitor room
9. Water services room
10. Salt water inlet
11. Salt water outlet
12. Salt water supply and recirculation tank
13. Fresh water coolers
14. Water treatment room
15. Boiler room
16. Motor room
17. Dynamometer
18. DSP hull
19. Shield tank
19. Platform to ventilation compartment
21. Parking area for fuel handling containers
22. Pond air extraction duct
23. High activity and tented enclosure
24. Cooler and fan
25. Change room
26. Dismantling area
27. Effluent collection and neutralising tank
28. Drying room
29. Monitoring room
30. Reactor tool store
31. Clean assembly room
32. Chemical loading platform
33. Access ladder to component hatch (Nuclear Compartment)
34. Refuelling platform

Fig. 5 (left) Cut-away views of the building for the submarine land-based prototype at Dounreay.

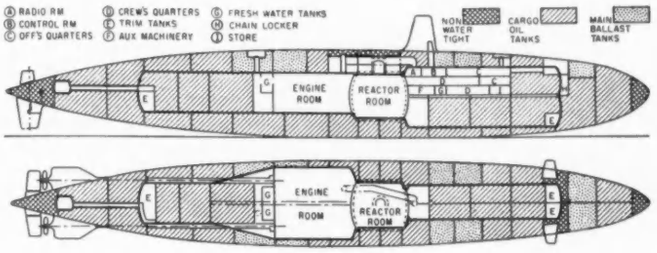


Fig. 6 (below) Mitsubishi submarine tanker design.

Submarine Advantage

Submarines may eventually prove to have advantages over surface ships for cargo carrying in certain conditions. The special case of sub-ice navigation to shorten journey length and to provide access to ice-bound ports has recently been quoted, but the submarine is also known to have advantages in terms of sea resistance. This advantage is illustrated by the graph in Fig. 7, which shows resistance against speed for submarines and surface vessels and was used by

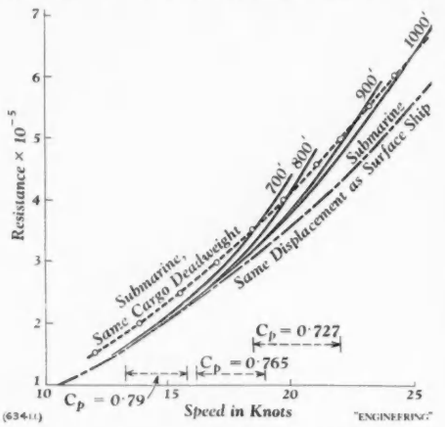


Fig. 7 Resistance against speed for surface ships and submarines of 80,000 tons displacement. Since a submarine cannot carry as much cargo as a surface ship of similar displacement, a fairer basis for comparison is the upper curve showing a submarine of the same cargo deadweight.

Mr. W. A. Crago, tank superintendent for Saunders Roe Limited, in his recent Leonardo da Vinci lecture "Transport On and Under the Sea." To achieve sufficiently long periods of submerged operation, nuclear propulsion is necessary.

Submarine Assessment

A recent paper on nuclear submarine cargo vessels presented to the North-East Coast Institution of Engineers and Shipbuilders, drew the conclusions (1) that it is unfair to impose restrictions on the dimensions of a submarine tanker; and (2) that a smaller, higher-speed submarine tanker would be more attractive. Fig. 8 shows power against speed for submarines of circular and eliptical section together with a surface tanker, all of 47,000 tons deadweight.

If there were no draught restrictions at the terminal ports, the circular form, with its superior performance to that of the surface vessel, could be used. Such a submarine would, however, be forced to follow the Cape route in the carriage of oil to the United Kingdom from the Persian Gulf and this disadvantage would outweigh the superior performance. For tanker routes other than United Kingdom-Persian Gulf, there was no indication that any easing of dimensional restrictions would favour the submarine because surface vessels could then be built with much larger deadweights than present designs. To investigate the second argument an estimate had been made which suggested that the maximum deadweight of a streamlined, circular-section, submarine which conformed with the dimensional limitations of a 47,000 ton surface tanker, was likely to be about 26,000 tons. Such a submarine would have an annual fuel bill at least four times that of the 47,000 ton surface vessel, when driven at a speed necessary to deliver the same quantity of cargo per year. Although the capital cost of the 26,000 ton submarine might be less than that of the larger-deadweight surface tanker, it was most unlikely that the saving in capital cost would offset the increased fuel bill. The advent of nuclear power was not likely to lead to any major changes in the fundamental design of commercial oil tankers. It was possible that some increase in service speed could be expected if nuclear fuel costs were reduced to very low values, but only when the surface vessels had reached their limit for high-speed operation would there be any incentive to develop submarine tankers. ("Characteristics and Performance of Nuclear-Powered Submarine Cargo Vessels," J. A. Teasdale.)

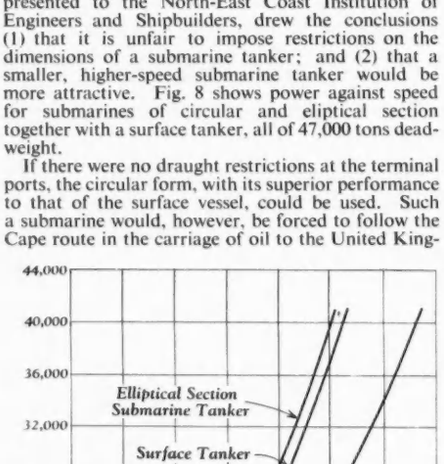


Fig. 8 Power against speed for submarines of circular and elliptical section together with a surface tanker, all of 47,000 tons deadweight.

Weight of Propulsion Plant

The specific weight of conventional marine propulsion plant ranges from 60 to 180 lb per s.h.p. for larger ships, depending on the machinery included in the estimate. Figures for the nuclear propulsion plants described in Atomic Review last week ranged from 166 to 200 lb per s.h.p., but the plant included was also unspecified.

Ship Prospect Comment

Suggestions that the Government should proceed at once with the building of a prototype nuclear propelled merchant ship were turned down last week by Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, and chairman of the Marine Nuclear Propulsion Committee. Technical appraisal had to be completed before such a step could be taken. The possibility that the replacement for the Queen liners may be powered by nuclear means has been considered.

Near Competitive Nuclear Vessels by 1961

Speaking in Utrecht recently, Mr. H. W. Bowker, head of the marine propulsion group at Harwell, said that nuclear powered ships with operating costs not more than 5 per cent higher than those of conventional vessels will be in service by 1961. If recent progress could be maintained nuclear powered ships were likely to be operating at competitive costs within 5 to 10 years. Professor M. Bogaardt, at the same meeting, pointed out that the advent of nuclear propulsion would lead to larger ships since smaller nuclear ships would not be competitive. They were speaking at a meeting in connection with the International Technical Spring Fair, held in Utrecht last month.

US Gas Cooled Marine Reactor

The General Dynamics Corporation has announced the selection of Westinghouse Electric Corporation as its subcontractor to develop the rotating machinery for a marine nuclear power plant. The overall project is directed towards development of a nuclear propulsion plant for merchant ships utilising a gas-cooled nuclear reactor, and is being sponsored jointly by the United States Atomic Energy Commission and the Marine Administration of the Department of Commerce. General Dynamics is the prime contractor for the Government and will design and develop the reactor at its General Atomics Divison at San Diego, California. Dynamics' Electric Boat Division at Groton, Connecticut, will have the responsibility for the design and the development of the propulsion plant.

Esso Propose Nuclear Tanker

The Esso Standard Oil Co. is reported to have proposed a cooperative nuclear-powered tanker project to the United States Government.

Ship Reactor Studies in Hanover

Pressurised-water and gas-cooled reactor propulsion systems giving 10,000 s.h.p. have been studied at the Technical University at Hanover.

Japanese Projects

In addition to the cargo submarine mentioned above and a 20,100 ton nuclear powered emigrant ship, also reported at the Geneva Conference, the Japanese are said to be considering an 80,000 ton tanker.

Automobile Engineering

NEW GAS TURBINE ENGINE FOR MOTOR CARS

Ford 704 Develops 300 h.p.

Preliminary details have just been announced, by the Ford Motor Company (USA), of a newly developed gas turbine engine which is suitable for both passenger cars and lorries. Known simply as "The 704," this new engine, which has been under development for two and a half years, is said to produce 300 h.p. Its weight is much less than that of a diesel engine of comparable power and its overall dimensions indicate that it could fit into the engine compartment of a normal six-cylinder car.

Until now, experimental gas turbine engines for passenger cars and lorries have employed only one stage of air compression. However, the Ford 704 has two, one of which is a supercharging stage. This is believed to enable the engine to deliver more power for a given size. The 704 weighs 650 lb complete with all accessories, needing only the addition of electrical power and fuel.

The method of operation of this two stage engine, which was recently demonstrated before the US Department of Defense is as follows. Air is drawn into the first compressor which operates at 46,500 r.p.m. Assuming an ambient temperature of 100° F, its four to one compression ratio then raises the air temperature to approximately 450° F. At full engine power the air flow is 2·7 lb per second.

The air then passes through an intercooler where its temperature is reduced to about 220° F. The intercooler is an integral part of this engine, employing a centrifugal type blower driven at 19,000 r.p.m., through a step-down gear, from the shaft of the low speed compressor.

After cooling the air passes to the high speed compressor and through another four to one compression stage which raises the temperature again, this time to about 650° F. The high speed spool operates at 91,500 r.p.m. Another 375° temperature rise is attained as the air passes through the exhaust heat exchanger and it enters the combustion chamber at roughly 1,000° F.

Fuel is added and the mixture burns in the primary combustion chamber. At 1,700° F the exhaust gases drive the high speed turbine that turns the high compressor spool. Supplying power to the turbine wheel reduces the temperature to about 1,350° F.

Additional fuel is added in the secondary combustion chamber to bring the temperature back up to 1,700° F. From here the exhaust gases pass through the power turbine, driving it at a speed of 36,000 r.p.m., and through two turbine wheels that drive the low speed compressor.

Next the exhaust gases move to the heat exchanger where they release heat to the incoming air after the second compression stage. They are rejected into the atmosphere at about 740° F, which is roughly the temperature of the exhaust gases from conventional passenger car engines.

The power turbine shaft, through a step-down gear arrangement, turns the drive shaft at 4,600 r.p.m. at full power.

Mr. B. T. Howes, associate director of engineering research and advanced product study at the Ford Motor Company, USA, said in announcing the new engine: "Our design team deliberately by-passed many conventional approaches to arrive at this concept." He added, "there are many other unusual features incorporated in the Ford 704. For example, we attain maximum fuel economy in the range of 25 to 100 per cent of power. Earlier designs are efficient only when operating at full power, with fuel consumption rising sharply as power slides below the 100 per cent level."

The Ford Motor Company expects to test the new engines in vehicles this year.

HYDRODYNAMIC GAS BEARINGS IN THE USSR

High Speed Grinding Spindle with Carbon Bushes

By Dr. S. A. SHEINBERG and A. M. KHARITONOV, ENIMS, Moscow, USSR

Abstracted by V. H. BRIX, B.Sc., A.C.G.I., Principal Scientific Officer, Ministry of Supply

Dr. S. A. Sheinberg and A. M. Kharitonov describe a successful application of hydrodynamic gas bearings in an article, "Aerodynamic Bearings for High Speed Motors and Turbines," which appeared in the September issue of Vestnik Mashinostroenie.

The authors were faced with the problem of developing a grinding head to run at speeds of 30 to 50,000 r.p.m. for grinding small diameter bores. Gas bearing work had been going on since 1950 at "ENIMS," the Machine Tool Development and Research Institute in the Soviet Union. Various troubles occurred with gas lubricated bearings, mainly due to shaft vibration with consequent bearing seizures, and difficulties in lining up the bearing bushes. Starting difficulties were also experienced and improvements in dynamic balancing had to be made.

This is all very interesting because the Soviet engineers were tackling the same problems of development as those which were encountered by Ford,[1] in this country, during the same period, and, they naturally evince a somewhat different approach.

The development culminated in the electric grinding spindle illustrated in Fig. 1. This shows the "ESH19" spindle intended for grinding diameters up to 1 in, and incorporates a 1 kW induction motor for 220 V, 3·9 A; cos ϕ = 0·85, ρ = 80 per cent; r.p.m. (synchronous), 48,000; diameter of gas bearing journals, 1·26 in; peripheral velocity of journals at synchronous speed, 264 ft per sec.

Rotor (2) is pressed on to the shaft which runs in cylindrical bushes 3·16 in axial length (l/d = 2·5). The bushes (3) tapered on the outside, are forced into the tapered housings integral with the motor end balls (4). The bushes are squeezed in by screwing up bolts (5) and (6). The end bells are bolted up flush to the end location faces of the motor body (7) by draw bolts (8). A thrust bearing collar (9) is fixed rigidly to each bearing housing so as to take axial loads. Screws (10) are part of the arrangement for lining up the bearings as described in greater detail below.

It will be seen that the bearings are pressure fed from the top, the idea being to suppress whirl, in exactly the same manner as the British gas bearings, the latter, however, embodying an axial groove to distribute the supply of pressurised gas. The authors explain the efficacy of this system of suppressing "half speed whirl" by saying that the extra load increases the shaft eccentricity by an amount just sufficient to overcome the whirl at the given operating conditions. With a pressure supply of 3 atmospheres, and a minimum gap of 0·16 by 10^{-3} in the load carrying capacity of a bearing of 1·26 in diameter by 2·16 in axial length is stated as 187 lb, which seems an extraordinarily high figure.* When the feed pressure at the top of the bearing is reduced to 1 atmosphere, the load carrying capacity is said to drop to 66·3 lb (24·3 lb per sq. in).* The supply of gas at pressure is, of course, very desirable, because it prevents the ingress of dirt and abrasive to the bearings.

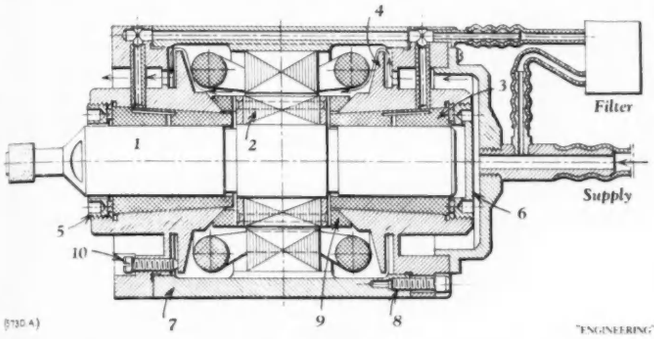


Fig. 1 (left) The ESH-19 grinding spindle has gas bearing journals of 1·26 in diameter.

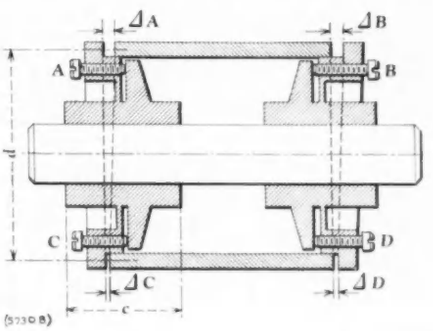


Fig. 2 (right) Lining up the bearings into motor-body on a dummy shaft.

The space between the bearing and plate and the right hand end of the shaft is pressurised from the adjacent bearing leakage so as to provide an axial load, thrust being taken by the left hand thrust plate. These thrust bearings are fed by the gas leaking axially out of their respective journal bores, the cushion so formed being strong enough to withstand the axial loads encountered.

The authors say that flexibly mounted bearings, that is, gimbal or diaphragm mounted, only work satisfactorily at speeds up to 20,000 r.p.m., above which vibration takes place. That is why they use rigidly mounted bearings as shown. However, the problem in this case is to line up the two bushes, the permissible misalignment of each within its own length being approximately 0·0001 in.

The bearings are lined up by a preliminary assembly into the motor body on a dummy shaft, as shown in Fig. 2. Clearly, if the bearings are in true alignment when mounted on the dummy shaft, the housing flanges will not necessarily mate with the motor body end faces, as shown by the various clearances ΔA, ΔB, etc. However, by adjusting the screws (these also appear as 10 in Fig. 1), a constant clearance of about 0·004 in is established at the location faces, the accuracy claimed being to within 0·0002 in. This gives the requisite alignment accuracy at the bearings, so that the end bells can be dismantled and finally reassembled when the motor has been built in and the proper shaft incorporated.

The bearing bushes themselves are of some interest. The bushes, tapered on the outside, consist of metal-loaded graphitic carbon (lead, tin and cadmium are mentioned as the filler). [It should be mentioned that plain carbon bushes are porous, unless impregnated with metal or plastic, and the porosity would be incompatible with the development of the pressure gas film in the bearing.] The bore is rough machined when the bush is fitted to the tapered housing. It is pressed in, axially, by suitable grub screws so as to be clamped tightly within the taper. The bore is then given a final machining. As, however, clearance is so very important, the diameter of the bore requires further adjustment to allow for machining error. This is done by screwing in the grub screws against the bush so that the additional compression due to the taper closes the bore in to the requisite degree.

The shaft steel is hardened up to 60 R_c. It is also deep frozen in liquid nitrogen in the course of its manufacture to cut down subsequent distortion. The combination of this steel and the metal-graphite is said to give a dry coefficient of friction as low as 0·04 under favourable conditions of surface finish.

Continued at foot of next page

* A rough check on figures given in the section on Dynamic Balancing suggests that the load capacity is about one tenth that given. This is, approximately, the value experienced with this size of bearing in this country.

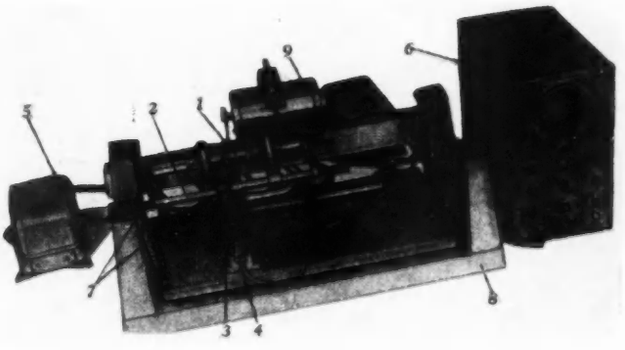


Fig. 3 Balancing machine must allow reduction of residual unbalance to within 0·000702 in.

IDEAS FROM THE USSR *Patents and Prediction*

The news that a leading United States concern, the Rand Development Corporation, is setting up an office in Moscow is evidence of the increasing seriousness with which American industry is treating Soviet advances in the field of science and technology. Their Moscow staff will study Russian technical literature and scientific developments, with the object of securing patent rights and manufacturing licences for exploitation in the US. Mr. James Rand, the corporation's president, who has made many trips to Moscow in recent months, has picked out semiconductor materials, medical equipment, oil prospecting equipment, computers and cancer research as the initial fields of search.

Rand Development Corporation of Cleveland, Ohio, is a patent holding company which specialises in looking for new ideas for US industry. This move represents an extension of the already very active search by American industry for new ideas in Western Europe. The Rand Development Corporation have reported that in their initial contacts their representatives have received considerable encouragement from Soviet officials, though a number of US industrialists are said to be sceptical of the extent to which, when detailed negotiations begin, the Russians will be prepared to share their scientific developments.

At the eighth Soviet Chemical Congress held last March, a number of fears were expressed regarding the possibility that non-Soviet countries might pirate Russian ideas. These fears appear to arise largely from lack of experience in the field of patent protection since a recent article in *Pravda* drew attention to the need to take steps immediately to protect the Soviety Union's priority in these scientific and technical innovations.

The belief that there is a great deal to be picked up in the Soviet Union was expressed by Sir Greville Maginness, the president of the Russo-British Chamber of Commerce, at the chamber's annual meeting held in India recently, and confirmed by Mr. S. F. Anfimov, in his speech as vice-president. Some indication of the far-sightedness and ambition of the objectives of Russian science was given in the latest issue of *Soviet Union* (No. 110). Prefaced by the following quotations from Alexander Nesmeyanov, president of the Academy of Science of the USSR: "without vision there can be no vistas. Without vision a person inevitably stops moving forward. Creative work and marking time are incompatible." The statement has a strong flavour of Western commercial enterprise or even of Jules Verne, but certainly no lack of vision. Professor Georgi Babat predicts that Muscovites will very likely celebrate the New Year 2000 in the rays of a man-made sun blazing at a height of some twenty miles above the earth: "Columns of electromagnetic rays sent out by the mirrors of four high-frequency stations near Moscow will converge high over the city. At the spot, a sun of white-hot molecules of nitrogen and oxygen will flare up. Nitrogen oxides, a valuable fertiliser generated by the heat, will be carried to earth by the rain and winds." To take full advantage of the right sun, Academician Vladimir Engelgardt foresees the development of methods of relieving the nervous fatigue of the organism much faster than is done in ordinary sleep: "we may learn to tender all the toxins of fatigue harmless in one or two hours," thus prolonging man's active life by twenty to thirty years.

Among other visions, all by the most eminent of scientists, are "spare parts" for the human body, cars propelled by tiny reception devices feeding from underground cables carrying high-frequency current; atomic airliners flying 10 to 12 miles above the earth at 3,000 m.p.h. and submarine sea transport; helicopters and moving pavements instead of cars in large cities; cultivation of the sea bed (very rich in food: a whale grows to maturity in 3 years; an elephant, though much smaller, takes 40 years); the use of explosives for metal shaping and forming; transmutation of elements to give man the metals he needs without expensive alloying; exploration of the planetary systems by space ships travelling at speeds approaching that of light—"photon rockets"—and many other startling developments.

(The article was based on extracts from *Report on the 21st Century*, published in the USSR.)

Concluding

Hydrodynamic Gas Bearings

DYNAMIC BALANCING

The authors cite an arbitrary safe limit within which the shaft is to be thrown out of its central, stable, running position by dynamic unbalance. This is given as 0·15 times the minimum gap under the limiting static load, which is 0·00012 in. The dynamic unbalance should therefore not move the shaft centre by more than 0·00002 in approximately.

Taking the rotor weight as approximately 1 Kg (2·2 lb), the unbalance moment due to this flying out at 0·00002 in radius is 0·0007 oz-in (= 0·05 gm-cm). Residual unbalance therefore has to be reduced to within this figure, and is accomplished by taking off metal on the rotor at 0·6 in radius, which means that the balancing machine (Fig. 3) should be sensitive to 0·032 gm. The rotor (1) is mounted in plain bearings lubricated with kerosine and is driven at 3,000 to 4,000 r.p.m. by the electric motor (9) through a thin belt of pvc tubing. The plain bearings are fixed in a frame (2) in such a manner that one end is within the plane of clamping on knife edges, while the other end is free to vibrate. The vibrations are detected at (3) by a piezo-electric gramophone pick-up and observed on the oscillograph screen. The balancing machine is decoupled from its surroundings by the supporting springs (7). Results of residual dynamic unbalance down to 0·0003 oz-in (0·02 gm-cm) are obtainable.

CONCLUDING REMARK

The life of high speed ball bearings decreases rapidly with increase in peripheral speed, the relationship between the two being expressed as the product Dn, diameter (mm) multiplied by r.p.m., which should not exceed 500,000 for the highest precision bearings. This corresponds to a peripheral velocity of 86 ft per sec. By replacing these with the gas bearings described, the "Dn" value has been trebled. Peripheral velocities of approximately 260 ft per sec are attainable with unlimited life and reliability.

The grinding head has produced work of the highest order of surface finish obtainable.

[1] G. W. K. Ford, D. M. Harris, D. Pantall. "Principles and Applications of Hydrodynamic-type Gas Bearings," *Proc.Inst.Mech.Eng., 1957*, vol. 171 No. 2.

GIANT HI-FI AMPLIFIER FOR MISSILE RESEARCH

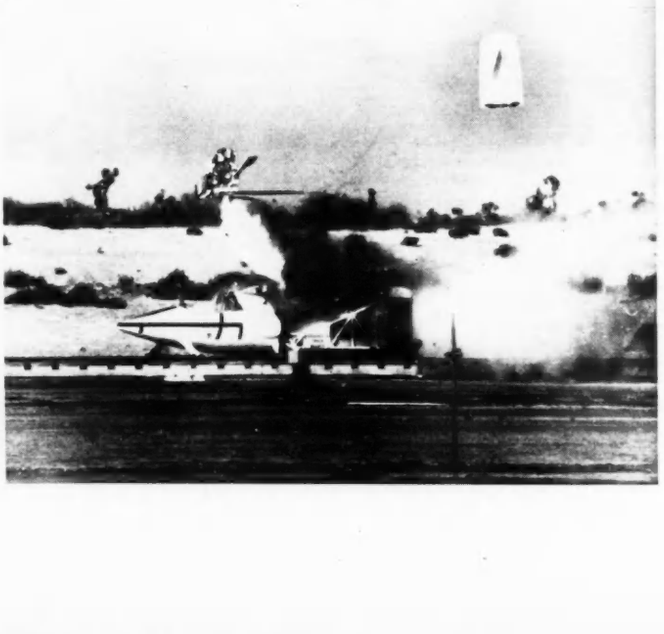
The world's largest and most powerful high fidelity amplifier has recently been built by the Industrial Electronics Department of Westinghouse Electric Corporation, NY, USA. The amplifier, which has an output capacity of 200,000 watts, will be used by the Lockheed Aircraft Corporation, Sunnyvale, California, for research and development in connection with the US Navy's Polaris guided missile.

Instead of being connected to a conventional loudspeaker system, the amplifier will be used to vibrate a 3 ft diameter platform. The main use of the amplifier will be to test missile components and sub-assemblies under accurately simulated flight conditions. Missiles will contain a small device to record the vibration phenomena components in flight. By taking a recording from a recovered missile and playing it back on the amplifier it is then possible, by attaching similar components to the output platform, to observe their behaviour under true flight conditions.

The amplifier is 24 ft long, 7 ft high, 3 ft wide, and weighs about 10 tons. "If you could connect this amplifier to some huge speaker system, you could probably carry on a conversation with a friend three counties away," said Mr. W. J. Delaney, manager of Westinghouse X-ray and Industrial Electronics Division. USA.

PREPARING TO LAUNCH THE X-15

American preparations for launching a manned rocket ship are now virtually complete. The X-15, which weighs 7½ tons, will be launched from a B52 bomber on which it will be carried below the wing. Preparations before launching will be watched by the bomber crew on a closed circuit television system. It is estimated that the flight of the X-15 will last about 90 sec and that touch the fringes of outer space. Heat is a major problem, as it is probable that the metallic shell will reach red heat, and to enable him to endure, the pilot will be in a five-layer aluminium suit.



The X-15 is fitted with a new ejector seat mechanism, and the illustration shows the sequence as carried out in trials at ground level. First the seat and pilot, in this case a dummy, are ejected from the test sled, and then the pilot is released from the seat. Even in the ground trials, the height reached was sufficient for the automatic parachute to operate and bring the dummy down safely. The pilot in the first attempt is expected to be 37-year-old Mr. Scott-Crossfield.

INERTIAL NAVIGATION *in the* SOLAR SYSTEM

A few months ago the high order of accuracy of an inertial guidance system was demonstrated during the voyages of the American nuclear submarines under the Arctic ice; although dead reckoning was the method actually used for navigation. An even more exacting application of inertial guidance, navigation in voyages about the solar system, was discussed by Mr. D. J. Cashmore of the English Electric Aircraft Company Limited, in a lecture to the British Interplanetary Society in London on 2 May.

The idea behind the method is old, but it has only been put into practice within recent years, the V.2 rocket being the first example. The present systems involve two basic instruments, the accelerometer and the gyroscope. In general, the former measures acceleration in one direction only, so that three accelerometers are required to deal with motion in three-dimensional space. Their readings are taken continuously and integrated to give a continuous record of velocity and position. The platform carrying the accelerometers must be stabilized with respect to some frame of reference (for space travel, the fixed stars are chosen), and this is done with three gyroscopes, preferably of the four-gymbal types, so as to avoid " gymbal lock " caused by the spinner axis being in line with one of the gymbal axes.

Interplanetary journeys can be divided into three navigation phases: launching in which the rocket leaves the ground and is placed in the required trajectory; mid-course or free fall when the vehicle moves freely through space and the motors are only used to apply any corrections necessary to maintain it on the correct course; and terminal in which it leaves the trajectory to land, enter a satellite orbit, or carry out any other required manoeuvre. In launching, any of the techniques now used in ICBM's and satellite vehicles can be employed, inertial guidance possibly being the best choice. The terminal phase will almost certainly be based on radar contact with the destination. For mid-course navigation, the use of radio and radar techniques is limited but inertial guidance offers great possibilities.

Gyroscope-stabilised systems are subject to slow drifts arising from such sources as out-of-balance masses, bearing friction, and torques caused by the necessity of having current leads to the gyro motors. Drift rates have been made quite small by recent developments in gyro construction, including the floating of the gyro in a fluid having the same density as the mean density of the gymbal, the use of air bearings, rotating the bearing itself, and employing two sets of gyros (as in the *Nautilus*; the sets are spun in opposite directions and used alternately so that their drifts cancel out). But even a drift rate of only 0·01° per hour would be intolerable for interplanetary travel, which would involve journey times of several months.

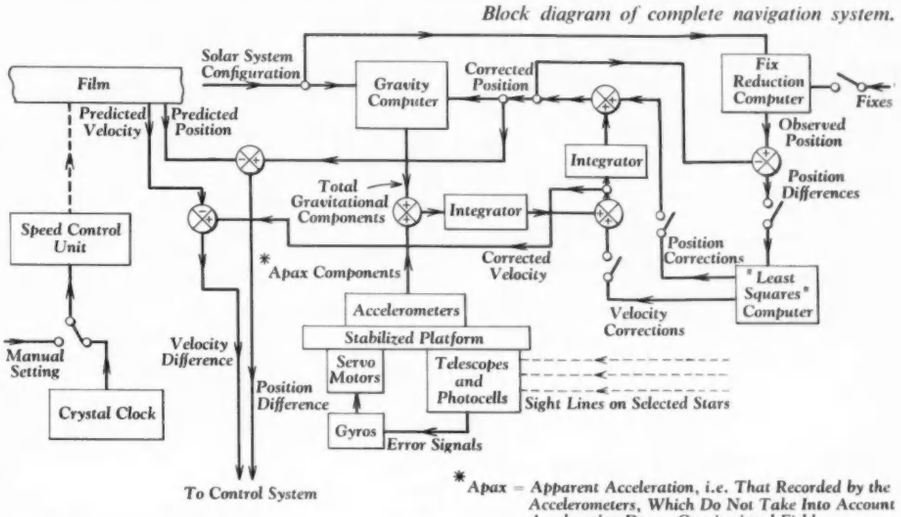
A solution to this difficulty is to stabilise the platform directly from the stars by means of telescopes and photocells, but also to introduce gyros to deal with steady-state position errors and to aid the initial alignment of the platform. In theory, two stars are needed to fix the table orientation, but since the vehicle itself may take up any orientation in space or may even be rotated artificially to simulate gravity it would in fact be necessary to provide more than two sets of telescopes and photocells, so that enough stars are visible through openings in the skin of the vehicle at any particular instant. The device might look like a planetarium projector in reverse.

An alternative design would employ an external system of this kind connected with the rocket by cable. This would be locked on suitable stars before launching, and then ejected from the vehicle when the free flight phase began, so that the fields of view of the telescopes would not be obscured by the rocket body. As in the case of the internal system, the accelerometers would be used to monitor the periodic corrections to the course made by operating the motors for short periods. The possibility of damage to the external unit by impact with the rocket during such operations was raised during the discussion after the lecture, and Mr. Cashmore decided that a rigid link between the two would be necessary.

Passing on from this comparatively simple device Mr. Cashmore envisaged what he considered to be the ultimate in navigation systems, as using a tape or film record containing the predicted trajectory of the vehicle together with the positions of the more important planets and satellites throughout the journey. From this information, a computer carried in the vehicle would determine continuously the total gravitational acceleration components acting on the vehicle. These would be added to the components of acceleration determined by the accelerometers (which are unaffected by gravitation in free fall, although this changes the velocity of the vehicle) and integrated by the computer to give continuously the velocity and position of the vehicle. Provision would be made for these results to be checked against those determined by planetary fixes and revised as necessary.

The actual velocity and position obtained in this way would be compared with the recorded predicted trajectory and any deviation would send signals to a control system to apply corrective thrusts. The equipment would incorporate a crystal clock for time measurement. Such a system has the advantages of being extremely flexible, accurate and completely self-contained.

Block diagram of complete navigation system.



* Apax = *Apparent Acceleration, i.e. That Recorded by the Accelerometers, Which Do Not Take Into Account Acceleration Due to Gravitational Fields.*

(6318) "ENGINEERING"

WATER POLLUTION FROM FACTORY WASTE

Several investigations at factories have been made by the Water Pollution Research Laboratory of the DSIR, Stevenage, in order to advise companies in the treatment and disposal of their waste waters. Among the effluents which have been examined are those from the manufacture of wafer biscuits, the dairy industry, egg packing and processing, the manufacture of chemicals, tanning, and the electro-deposition of metals. In some instances it has been shown that large reductions in the strength and polluting character of waste waters could be made by inexpensive modifications to manufacturing processes.

For example, minimising spillage, by improved drainage of churns before washing and by other similar measures, reduced the load of five day BOD (biochemical oxygen demand) discharged per day from a milk processing factory by almost half. At an egg processing plant, attention to the collection of defective eggs and to the method of washing contaminated equipment, reduced the five day BOD load from the plant to approximately one quarter of the original value. Investigations have also shown that the BOD load and quantity of suspended matter in the waste waters from a wafer biscuit factory could be greatly reduced by collecting the batter residues before the equipment was washed.

The results of many other studies of sewage effluents, and their effects upon natural waters, are given in the annual report of the Water Pollution Research Laboratory, published by HMSO, London, 7*s*.

WIND POWER GENERATOR PROGRESS

In the 38th annual report recently published by the Electrical Research Association of Leatherhead, Surrey, progress of wind power research is said to have been stimulated by two encouraging new developments. One is the commissioning of the first prototype windmill to be built at a competitive cost for feeding into a network. The other is the initiation of tests on the first automatic loading schedule for a windmill operating in a remote area. The latter refers to the 8 kW Allgaier machine which has been moved from its site at Cranfield to one of the outstations of the Nature Conservancy at Aviemore, Inverness-shire, where promising early results have been obtained with the automatic load distributing device evolved by the ERA.

The Ministry of Power has continued to support financially the work at Cranfield on windmills operating with an a.c. network, and the Ministry of Agriculture, Fisheries and Food is supporting the work on small and medium scale machines for isolated operation.

A 25 kW machine, built for the Ministry of Power by Dowsett Holdings Limited, has been constructed at Cranfield and the ERA has designed a protective device to enable it to be shut down in an emergency. This machine has now been erected in the Isle of Man where it is feeding energy into a small network supplied by diesel driven generators. This is the first installation operating in this way in Britain and detailed records of performance are now being obtained.

A SEMICONDUCTOR TETRODE

Performs Functions Previously Impossible with Single Device

A new four-terminal semiconductor device, which will perform a number of electronic functions that previously either could not be obtained at all, or only with extensive circuitry, has recently been invented at Bell Telephone Laboratories, NY, USA.

The device, known as the field effect tetrode, can be made to function as a transformer, gyrator, isolator, non-distorting modulator, or a short-circuit stable negative resistance. Laboratory models have been produced by the inventors which corroborate the theoretical predictions for operation of the device. This theory grew out of work previously reported on a field effect current limiter.

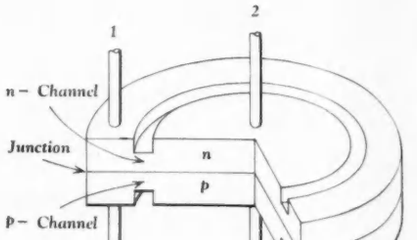
The tetrode is composed of a disc of semiconductor (see drawing) with a diffused junction. A circular trench is cut and etched into each face of the disc, to within about 1 mm of the junction on either side. Two leads are then attached to each face, one inside the trench, the other outside. When a voltage is applied across the junction, the thickness of the depletion layer adjacent to it is increased or decreased, depending on the direction of the biasing voltage. This in turn increases or decreases the resistance of each channel between the bottom of the trench and the junction.

Functionally, the device has no analogue, either in electron tubes or in previous transistors. The tetrode will function either as a transformer or a gyrator, depending on the polarity of the biasing voltage. As a transformer, it has a very decided size advantage for low frequency use, although it does not afford d.c. isolation. As a gyrator, it should be of considerable circuit interest. (A gyrator is a non-reciprocal four terminal network which behaves similarly to a transformer, while exhibiting a 180° difference in phase shift depending on the direction of transmission.) One gyrator function is impedance inversion. For example, it should be possible to use the new device to convert the reactance of a miniature capacitor into that of a high-Q inductor.

If the device is biased properly, it will function as an isolator, allowing the passage of alternating current in one direction only.

According to its inventors, one of the most important applications for the new device may be as a distortionless modulator, or electronically controlled resistor for large signals. In this use, a relatively low frequency control-voltage varies the width of the depletion layer, and thus the resistance of the device. Simple capacitors act as high-pass filters to isolate the control-voltage from the signal, if the frequency ratio is maintained at a high level. The signal voltage does not appear across the junction and has no effect on the depletion layer. Therefore, it can be magnitudes higher than the control voltage, without being distorted by self-modulation. For the same reason, it is not limited by junction capacitance.

If a direct connection is made between the inner lead on one face and the outer lead on the other, the device will function as a two terminal a.c. short-circuit stable negative resistance. In the experimental models produced at Bell Laboratories, this performance has been achieved over a range of about 30 to 250 V, at 0·6 to 0·1 mA, in a boron-doped silicon crystal with a phosphorous diffused junction.



Four terminal semiconductor.

WHY HAVE ACCIDENTS?

Research is being intensified almost everywhere into the causes of road accidents, particularly in the United States where the Government has allocated very large sums for the purpose. The integrated programme of research now being carried out began on a nationwide scale in 1951 " when the Pentagon realised that casualties to servicemen in traffic accidents exceeded those in combat in the Korean war." The US Defence Department allocated $250,000 a year for accident research and appointed a psychologist to take charge, Dr. Ross McFarland, of Harvard's School of Public Health. This appointment reflected the view that the causes of many if not most road accidents lay deep in the psychological make-up of the drivers involved.

Here are some extracts from findings so far, taken from an article entitled " Science Studies the Driver " published in *The Lamp*, the magazine of Standard Oil Company (New Jersey) (vol. 40, No. 4). " Most accidents today touch almost all aspects of man and his environment "; " the drinking driver is involved in more than half the fatal accidents over the past ten years. Recent research has been able to pinpoint the ratio of danger to the degree of alcohol consumption. The driver with an alcohol blood content of 0·15 per cent by weight, likely after perhaps six bottles of beer, is ten times as apt to have an accident as the one who has drunk a third as much "; " excessive smoking, it has been found, can sometimes affect both vision and general alertness, especially in high altitudes or under conditions of faulty ventilation "; " even though mature drivers, in general, tend to be safer than young ones, advancing years bring some problems. . . . For example, the amount of light required to see a dimly-lit object doubles, among adults, every 13 years "; " later stages of extreme fatigue quite commonly produce highway hallucinations. Out of a group of 50 long-haul truck drivers who were interviewed, 30 reported that when driving very late and very tired they had seen in the road ahead such imaginary objects as a herd of mules, a flock of sheep, and, in one case, an old southern mansion athwart the highway "; " there is not necessarily a relationship between intelligence and safe driving . . . emotional stability is far more important than intelligence."

The findings of the research so far suggest that straight propaganda such as the current " Be a Better Driver " campaign in Britain may not have much effect at all, because drivers tend to dissociate themselves from the body of their fellows. A points system for being faulted, leading to the withdrawal of licence may be much more effective. But the deep psychological causes will be harder to remove; maladjustment and drink are only two.

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers

CROYDON
Annual General Meeting. Various short papers by branch members. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 28 May, 7.15 p.m.

HOVE
Annual General Meeting. " Lighting and Colour," by A. Chappell and A. Matthews. Brighton, Hove and District Branch. New Imperial Hotel, First Avenue, Hove. Thurs., 28 May, 6.45 p.m.

WOLVERHAMPTON
Annual General Meeting. Wolverhampton and District Branch. Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton. Sat., 30 May, 7 p.m.

Chemical Society

LONDON
Various short papers for reading and discussion. Thurs., 4 June, 7.30 p.m.*

COVENTRY
" Polyethers," by Professor G. Gee. Birmingham Branch. Offices of Courtaulds Ltd., Coventry. Fri., 29 May, 7 p.m.

Combustion Engineering Association

GLASGOW
" Economic Purchase of Coal for Small Plants," by Dr. G. Armstrong. Grand Hotel, Charing Cross, Glasgow, C3. Wed., 27 May, 10.30 a.m.

Helicopter Association

LONDON
" Some Design Aspects of Tandem Rotor Helicopters," by J. D. Sibley and C. H. Jones. Royal Aeronautical Society, 4 Hamilton Place, W1. Fri., 5 June, 6 p.m.

Institute of Metals

LONDON
" The Atomic Mechanisms of Fracture," by Professor N. J. Petch. Thurs., 28 May, 6 p.m.

Institution of Civil Engineers

LONDON
" The Cape Town Wemmershoek Water Scheme," by Dr. S. S. Morris. Tues., 26 May, 5.30 p.m.*

Institution of Electrical Engineers

EDINBURGH
Annual General Meeting. " The Automatic Digital Recording of Experimental Values," by W. H. P. Leslie. Scottish Centre. Carlton Hotel, North Bridge, Edinburgh. Wed., 27 May, 7 p.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Thurs., 28 May, 6 p.m.*

Royal Institution

LONDON
" Some Principles of Clock and Watch Design," by Sir Harold Spencer Jones. Wed., 27 May, 9 p.m.

Royal Society

LONDON
" Kinetics of the Base-Catalised Bromination of Ethyl Nitroacetate," by R. P. Bell and T. Spencer; and " The Point of Oxygen Attack in the Combustion of Hydro-carbons—II, The Formation and Origin of Ketones," by C. F. Cullis, F.R.F. Hardy and D. W. Turner. Thurs., 28 May, 4.30 p.m.*

Royal Statistical Society

LONDON
" Optimum Experimental Designs," by Dr. J. Kiefer. Research Methods Meeting. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 27 May, 5 p.m.* (Note change of date.)

Women's Engineering Society

LONDON
Annual General Meeting. Hope House, 45 Great Peter Street, Westminster, SW1. Wed., 10 June, 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, SW1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, SW1. (ABBey 5160.)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (TEMple Bar 7676.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128.)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W1. (REGent 3335.)
Royal Statistical Society, 21 Bentinck Street, London, W1. (WELbeck 7638.)
Women's Engineering Society, 25 Foubert's Place, London, W1. (GERrard 5212.

On the Shelf

By Frank H. Smith

On behalf of the British Scientific Instrument Research Association, Taylor and Francis are publishing *Instrument Construction*, a translation of the Russian journal. The rate is £6 per annum but technical college and university libraries can get half rates.

Another contribution to the literary avalanche comes in the fact that the *Journal of Research* of the US Bureau of Standards will, from 1 July, come in four parts (even Gaul had only three): A, physics and chemistry—bimonthly; B, mathematics and mathematical physics (quarterly); C, engineering and instrumentation (quarterly); D, radio propagation (bimonthly). A and D are $4·75 and the other two $2·75 a year but it comes cheaper if you emigrate to the US.

Honestly, there's no end to it when you make a bloomer. Remember my Fairey (*sic*) soapflake on 1 May? Well, there hasn't been a Fairy soapflake since 1937. They're all Sylvan nowadays. So is my face washday red?

Isn't it extraordinary how you don't read about a thing for weeks or months (or even years) and then, all of a sudden, you get a surfeit. Aslib holds a conference on technical writing (despite what was said there I still maintain that it *was* chiefly writing and not authorship) and then, blow me down, if, in the same month, the *Journal* of the Junior Institution of Engineers doesn't have a paper on "The Scope of Technical Authorship and Illustration," by J. C. Y. Baker. Mr. Baker is a man who has obviously given some thought to this subject as he read a similar paper in January, 1954.

This country's old original "space-boys" (British Interplanetary Society of 12 Bessborough Gardens, London, SW1) announce their ability to supply back issues both of their *Journal* and of the new *Spaceflight*. The former, covering 1946-56, are £3 per bound volume and £2 per unbound (both are earthbound) and the latter, of which there is only one volume, is at the same rates.

Hot news from *Soviet News* of 6 May. A party of scientists is off to study the origins of the Yukagirs, and Vasily Uvachan, one of the first Evenk scientists, has written a history of the Nganasan, Golgan, Nentsy, Slekups and Evenks. I offer this as some small contribution to the reasons why we shall never understand the Russians.

I recently gave a note about publications of the Mechanical Engineering Research Laboratory of DSIR at East Kilbride. Those of you who made a mental note of this should now dementalise it and substitute National Engineering Laboratory. In other words, for MERL read NEL.

Chapman and Hall have now got out their tentative publishing programme for April-June. This covers their own books and those of Wiley and of Reinhold. A card to 37 Essex Street, WC2, will bring a copy.

I have remarked before on the poverty of invention when it comes to terms of engineering innovations. (I believe I instanced "fatigue.") Now, I see, there is a tendency to refer to tunnels for traffic intersection as "fly-unders"—the converse, one assumes, of fly-over. Why not coin a brand new word like "trunnel" (traffic tunnel) or "carrow" (car burrow), or a "trasubage" (traffic subterranean passage). Yes—trasubage is the one.

Symbol of the modern age
Is the Hyde Park trasubage.

A news sheet from the director's office of the Toledo Public Library (called *The Tee-Pee*) dated 13 April, mentions little Frankie's page of directory "reviews" of 6 March and says "It is by finding time (often hard) to scan such reviews that TPL's book orderers can keep its resources so comprehensive and up-to-date." We get around.

STABILITY IN HIGH SPEED FLIGHT

The Potential Theory of Unsteady Supersonic Flow. By JOHN W. MILES. *Cambridge University Press, Bentley House, 200 Euston Road, London, NW1.* (45*s*)

In this age of supersonic aeroplanes and guided missiles, the importance of the theory and practice of supersonic flow cannot easily be over emphasised. Experimental investigations of steady supersonic flows in wind tunnels can now be performed reliably by means of well established techniques, but similar investigations for unsteady supersonic flows have not yet attained the same degree of perfection, and reliable information is somewhat scanty at present, with the result that designers often have to rely on very inadequate data for flutter or stability calculations. This state of affairs makes the theory of such flows even more important than the corresponding theory for steady flows.

The non-linear character of the equations of motion poses mathematical problems, even for ideal fluids, which are not likely to be solved for a long time to come, and aerodynamicists have to be contented in the main with the results of approximate methods of calculation. The simplest of these rigorous approximate theories is that which results from a linearisation of the equations of motion on the assumption that the disturbances created by the passage of a body through an otherwise uniform flow are small in some sense; this limits the bodies which can be treated to those whose surfaces are inclined only slightly to the undisturbed flow, but this is not always a serious limitation since such bodies are particularly appropriate for high-speed flight and many practical configurations fall into this class. Before using approximate theories of this kind, the results ought to be compared with experimental observations in order to establish confidence in them and to determine their limits of applicability. In many cases, it is found that theory and experiment can be brought into good agreement by changing some of the calculated constants in the theoretical formulae, thus providing a basis for interpolation and extrapolation of experimental tests. This approach to the use of the linearised theory of steady high-speed flows is usually possible because a large amount of experimental evidence is available, but is made difficult in the case of unsteady flows due to the lack of experimental results mentioned previously. Unfortunately, the linearised theory of unsteady supersonic flow can be expected to be somewhat unreliable in general owing to the inherent limitations of the approximation, with the result that a somewhat unsatisfactory state of affairs exists in this respect at the present time.

All these difficulties do not mean that linearised unsteady high-speed flow is not a worthwhile topic for research, for an extensive investigation of it is required before the non-linear corrections to it can be calculated, and much effort has been expended on this subject in recent years. Professor J. W. Miles has enriched our knowledge in this field with an extensive series of papers published over the past twelve years and his monograph is a most welcome and authoritative account of his own and other researches, and provides a valuable addition to the literature on high-speed flow. As with the linearised theory for steady flows, that for unsteady flows leads to problems of quite considerable mathematical interest in their own right, and the description of the methods which have been adopted for their solution will recommend Professor Miles's book to a wider class of readers than those who are interested primarily in fluid mechanics.

Professor Miles commences his exposition with a systematic discussion of the linearisation process, showing how differing boundary-value problems can lead to different linearised equations (a point that is not always appreciated properly), and goes on to consider transformations of the subsonic and supersonic wing equations. A chapter on the theory of two-dimensional wings follows, the results of which have been applied widely to practical flutter analysis in what is known as *strip-theory*, in which the local flow is assumed to be two-dimensional. Two-dimensional problems, as well as those for *simple* planforms (for which the normal component of flow at all edges is supersonic) which are dealt with next, are the simplest of all, and may be said to be solved completely in principle.

The monograph continues with chapters on the problems arising in connection with rectangular wings, quadrilateral wings, slender wings, delta wings, and low aspect-ratio rectangular wings. These topics are treated very clearly and concisely; in most cases several methods of attack are explained, and it appears that all the available methods are given at least a mention, which makes the monograph particularly valuable for the research worker. Special attention is given to harmonic oscillations and transient motions, and there are some very useful figures giving examples of stability loci.

The theory of slender non-planar bodies is developed in a separate chapter, and a further chapter contains some remarks on non-linear problems, with particular application to slowly oscillating two-dimensional aerofoils and hypersonic flows. The work concludes with an appendix on reverse-flow theorems.

There is an extensive bibliography, containing more than 300 references, which must include nearly all the papers published on this subject up to 1956, and indexes of notation, subjects, and authors. The format and printing are up to the highest standards of the Cambridge University Press.

In spite of the inevitable condensation which occurs when a subject of this scope is treated in a comparatively slender volume, the exposition is very clear throughout, and full references to original papers are given, so the reader who requires more information can obtain it without much trouble. The book is most suitable for research workers in the field of unsteady flow and aerodynamicists who are concerned with flutter and stability and control, but the more general reader will find much of interest and will be grateful to Professor Miles for having avoided, as far as possible, the use of difficult concepts like Hadamard's finite part of divergent integrals. Nevertheless, those who are not interested in formulae which are more than one inch long should ask somebody else to read it for them.

G. N. WARD

CROSS SECTIONS OF THE UNIVERSE

Handbook of Physics. Edited by E. U. CONDON and HUGH ODISHAW *McGraw-Hill Book Company Incorporated, 330 West 42nd Street, New York 36, N Y* ($24·25); and *McGraw-Hill Publishing Company Limited, 95 Farringdon Street, London, EC4.* (194*s*)

Handbooks devoted to most branches of engineering and to many aspects of technology exist in plenty and, as edition follows edition, they tend to become progressively more bulky and correspondingly less legitimately describable as "hand" books. Until quite recently physics has not been represented on the handbook lists but McGraw-Hill have now made good the omission by publishing two handbooks on physics within twelve months of one another.

The first of these, sponsored by the American Institute of Physics, conforms more nearly to the traditional handbook pattern, consisting mainly of a comprehensive selection of numerical data presented in tabular and graphical form. The second is the work under review, edited by Professor Condon and Dr. Odishaw, the aim of which is to provide a broad survey of the present status of the chief branches of physical science with which every professional physicist ought to

be familiar or might well have occasion to use.

The literature of physics has become so vast and is accumulating so rapidly that attempts to cover the major part of the subject in a single volume at anything above an elementary level have long been abandoned. A synthesis such as this summarising the present outlook in so large an area of physics at graduate or post-graduate level represents, therefore, a very ambitious undertaking and one that must have imposed a heavy burden upon its editors.

Originally planned nearly ten years ago when both editors were associated with the National Bureau of Standards, its success is very largely dependent upon the choice of the 88 specialists who have contributed to it. All but some half dozen of these are American, most of them being well known members of the staffs of universities, research institutes or industrial establishments. Professor Condon has himself contributed 17 chapters and considerable care has clearly been taken to secure uniformity of treatment and to avoid overlapping.

Lists of references at the ends of nearly all the chapters are a valuable feature. They vary considerably in length, are usually numbered and include standard texts, review articles and papers with dates as recent as 1956. To overcome the tendency for parts of the material to become out of date while being set up in type arrangements were made to insert more than the customary number of additions and corrections at the galley proof stage.

The text consists of 1,448 large format double column pages the first 884 of which are devoted to the mathematical tools employed by the physicist and to the classical subdivisions of physics. These include the mechanics of particles and of rigid and deformable bodies, electricity and magnetism, heat and thermodynamics, and optics. Naturally the exposition here is largely along familiar classical lines but this is supplemented by relativistic formulation wherever appropriate and by chapters on more recent developments, such as quantum dynamics, rheology, semiconductors, statistical mechanics, vibrations of crystal lattices and superfluids. The chapters on control mechanisms, electric and electronic circuits and experimental stress analysis will be of special interest to engineers.

The remaining 564 pages are concerned with the newer departments of physics, grouped under the main headings of atomic physics, the solid state and nuclear physics. The first section deals with atomic structure, spectroscopy, X-rays, and ends with an elaborate discussion on the fundamental constants of atomic physics. The second includes chapters on crystallography and X-ray diffraction, ionic crystals, photoelectricity and thermionics, and a comprehensive account of the properties of glass. The last section summarises our present knowledge of the structure and properties of the nucleus, describes the techniques developed for the acceleration of charged particles to high energies and for their detection in the cloud (but not in the bubble) chamber and in photographic emulsions. Methods of measuring nuclear masses and nuclear moments are considered, and there are chapters on cosmic rays and meson physics. Much useful data here as elsewhere is tabulated and exhibited graphically. Tables of units and conversion factors are assembled in an appendix. Detailed tables of contents preface each of the nine parts of the book and supplement the extensive general index.

Some omissions are inevitable even in a work of this scope among them being electron optics, geophysical prospecting, meteorology and radio astronomy. There will probably, however, be general agreement that everything included merits inclusion and that, on the whole, the space available has been judiciously apportioned among the vast range of topics competing for attention. The treatment is of necessity highly condensed and quite unsuited to the student learning physics, whose understanding can only be securely based on an ampler investigation of the particular cases from which principles of wide generality have been distilled and on a more critical examination of their implications. To the mature physicist it is an advantage to be able to locate essential information expeditiously and to have the means of ascertaining with a minimum of exertion whether particular problems in fields bordering his main interest are amenable to solution and, if so, what the solutions are, or where they may be found. This massive compendium supplies a most valuable single source of reference that will often save him a preliminary search through a shelf full of texts and journals.

G. F. HERRENDEN HARKER

FAST PATH THROUGH A MAZE

Digital Computer Components and Circuits. By R. K. RICHARDS. *D. Van Nostrand Company Incorporated, 120 Alexander Street, Princetown, New Jersey, USA;* and *D. Van Nostrand Company Limited, 358 Kensington High Street, London, W14.* (64*s*)

System Design of Digital Computers at the National Bureau of Standards: Methods for High-Speed Addition and Multiplication. National Bureau of Standards Circular 591, Section 1. *Superintendent of Documents, US Government Printing Office, Washington 25, DC, USA.* (20 *cents*)

The design of digital computers has advanced rapidly since the first electronic machines were built over ten years ago. Advances in design were made in a number of centres during this period and these have been described in a variety of journals, but the newcomer to the field is largely at a loss for want of a starting point. Many techniques have been developed and much has been written but until now no coordinating overall guide has been available. The publication of *Digital Computer Components and Circuits* is most valuable in setting the scattered information in logical order and in bringing the whole field within the scope of one book.

Mr. Richards, already well known for his book on *Arithmetic Operations in Digital Computers*, in this present book has with equal lucidity been able to describe the actual circuits and components used to perform the logical operations he described in the earlier volume. After an admirable introductory chapter in which he briefly reviews the history and organisation of digital computers and emphasises the aspect of reliability, he deals chapter by chapter with each of the separate methods of computer design. Diode switching circuits, electron valve systems, transistor systems and magnetic core systems are each very adequately described. The emphasis in each chapter is on basic concepts and the general functioning of the circuits rather than on details of design techniques so that a knowledge of the operation of any of various systems may be rapidly acquired. Alternative and improved methods in the various systems are included and compared.

Three chapters on various methods of storage of information follow: non-magnetic methods (including cathode ray tubes and delay lines) storage on magnetic drums, tapes and discs and finally magnetic core storage. The second of these chapters includes an excellent account of the various methods of magnetic recording used and the last deals with problems of core selection and regeneration of information; non-destructive read-out of core stores is also briefly described.

A chapter on various circuits and special electron tubes developed for decimal counting follows. The remainder of the book is devoted to the description of a collection of miscellaneous components and circuits, including cryotrons, cold cathode tubes and thyratrons among other devices and finally analogue-to-digital and digital-to-analogue converters are considered, including the use of Gray or cyclically progressive codes.

Each chapter is followed by an extensive bibliography covering the subjects dealt with in the text, references being made to both British and American publications.

The book is well written in a characteristically clear style which enables the reader, be he engineer, programmer, or business executive, to gain a rapid understanding of the functioning of digital computers and to be in a position from which he can assess their performance and reliability.

Coupled with the trend of computer elements towards increase in speed of operation is the research in design towards faster logical circuitry for the arithmetic operations to be performed. The choice of circuitry is ultimately a balance between a desire for speed and a desire to keep the overall cost down. It is important therefore to be able to design the fastest possible circuits with any given computer components in the most economical way. Such a study has been undertaken for the computers SEAC and DYSEAC and the results of the investigation have been published in an NBS circular entitled *System Design of Digital Computers at the National Bureau of Standards: Methods for High-Speed Addition and Multiplication.* The subjects of the book are technical and, though written primarily for the computer design engineer, are fully and clearly described so that the treatment should offer no difficulty even to the relative newcomer; the matter is however specialised and will possibly therefore not have a wide interest.

A 53 bit parallel binary adder is described in which an addition time of 1 μs is achieved using 1 Mc circuitry with multiple clock phases. The problem in designing such an adder is that of the propagation of a carry digit over the full word. This problem is tackled by methods of Boolean algebra, and by using a number of auxilliary carry functions the design of an adder is evolved using a system of gating with five clock phases; no gate having more than six inputs. The complete logical equations for the adder are given in full. The adder described was designed for use in a short-cut multiplier. The usual process of multiplication using a succession of additions to the partial product may be speeded up by sensing strings of 0's and 1's, performing an addition or subtraction at the beginning and end of such a string and merely shifting for the number of 0's and 1's present. Theoretically this needs a large number of shift paths and in practice the number must be restricted for reasons of economy: a study of the effect of this restriction is undertaken from which it is seen that no serious loss in speed occurs if the maximum shift is limited to three digits. A statistical study of the effectiveness of this short-cut method of multiplication is given and the results plotted in graphical form. It may be seen from this that the increase in speed using short-cut multiplication under the limitations described above is about 2·5 times that of the usual method.

A number of references is given to American literature on design techniques.

J. P. HOLLAND

The Reviewers

Professor G. N. Ward, M.A., is head of the department of mathematics at the College of Aeronautics, Cranfield. He is the author of *Linearised Theory of Steady High-Speed Flow*, another volume in the same series as the book under review.

Mr. G. F. Herrenden Harker is an M.A. of Cambridge University and is at present lecturer in physics at the University College of South Wales and Monmouthshire.

Mr. J. P. Holland, M.A., is engaged in the logical design of electronic computers at the Bracknell laboratories of Ferranti Limited. He holds a Cambridge degree in mathematics.

HIGHER WORKING TEMPERATURES FOR CAST IRON?

The standard practice in this country for iron castings used for steam applications where dimensional stability is important, such as in steam turbine engineering and for valves and for pipe fittings, is to limit the temperature to below 232° C (450° F). For some time designers and engineers have considered this temperature unrealistic in view of the technological advances made in the production of iron castings. The question of raising this specified limiting temperature is important, since with more efficient steam plant operation, higher temperatures and pressures are used, and there is a danger that iron castings may be replaced by other materials for no valid technical reason.

In America there is a standard ASTM specification for grey iron castings for pressure-containing parts for temperatures up to 343° C (650° F). This specification was prepared in conjunction with the American Society of Mechanical Engineers and represents standard practice for boiler and pressure vessel applications. In the United Kingdom, in a few isolated cases where foundries have been proved to have satisfactory control, the use of cast iron for valves at temperatures up to 316° C (600° F) at pressures not greater than 300 lb per sq. in has been sanctioned. Such castings are subject to very rigorous tests before acceptance and to pressure tests at 450 and 500 lb per sq. in. However, iron castings for some applications at temperatures above 232° C (450° F) will not at present be generally accepted.

The dimensional stability of iron castings is determined by their growth and creep resistance, provided they have been given an appropriate stress relieving heat treatment before service. To supply the necessary data to permit the various authorities to raise the present temperature limit, an extensive programme is being carried out by the British Cast Iron Research Association to evaluate the growth and creep characteristics of a very wide range of iron castings. The results of the growth tests carried out in this programme have now been fully reported.* Growth and scaling tests were carried out on 35 cast irons, including 20 flake graphite cast irons, 14 nodular cast irons and a blackheart malleable cast iron. Unalloyed pearlitic flake graphite cast irons with various carbon, silicon, manganese, sulphur and phosphorus contents, and alloyed irons containing nickel, chromium and molybdenum, have been studied. The as-cast and annealed ferritic nodular cast irons used were produced from various raw materials and contained alloying and trace elements.

No growth was recorded in any materials at 400° C (752° F) and below, in tests of up to 64 weeks in air and up to 49 weeks in steam. These results confirm the view that the present limiting temperature is unrealistic and that a temperature of 343° C (650° F), similar to that used in America, would be satisfactory.

Tensile and hardness tests carried out on specimens exposed in air and steam confirmed that all cast irons were structurally stable at temperatures of 400° C (752° F) and below, for the periods mentioned. No change in tensile strength and hardness was revealed in irons exposed at this temperature. Short-time, high-temperature tensile tests were carried out on all materials, confirming the results of other workers and showing that cast iron retained its strength at 400° C (752° F) and below.

Growth data are of primary importance since dimensional stability is expected to be influenced by growth rather than by the magnitude of the stresses applied. However, though stresses are generally low, creep tests are also in progress to supplement the growth data already established and the results of these will be reported shortly. It is anticipated that active steps will then be taken to modify the present limits for service conditions of iron castings in steam engineering.

* BCIRA *Journal of Research and Development*, 1959, vol. 7, February, pp. 478-566.

PURE REFRACTORY PROGRESS

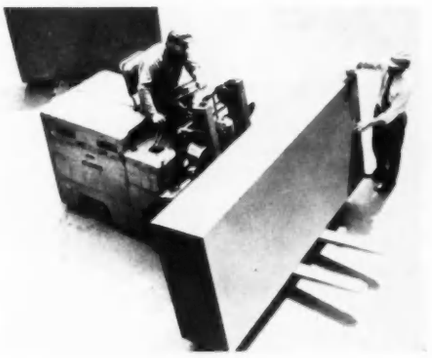
An answer has now been found to the question "can anyone make an impervious boat in 99·9 per cent thoria?"—such an answer would, however, be advertising. Suffice to say that the last five years have seen many forward strides in the field of pure refractories made by Morgan Refractories Limited, Neston, Cheshire. Forsterite, yttria, gadolinia and samaria are their working companions; but Purox recrystallised alumina, magnesia and thoria must take their *place d'honneur*. A feature of an exhibition held by this company of Purox refractories was a large 7 in diameter cylinder about 4 ft long, but this took its place among other notable exhibits including alumina radomes and a 10 in by 10 in ball mill, among thermocouple lead insulators less than $\frac{1}{16}$ in in diameter, and among crucibles, boats, discs and blocks in that difficult-to-fabricate material—magnesia.

Refractories and chemical compatibility are synonymous with purity—this, therefore, has been the first consideration in Morgan's making the materials. 99·7 per cent recrystallised alumina will withstand 1,950° C; 99·9 per cent impervious thoria will withstand 2,600° C—and attack by molten titanium, hafnium, uranium, zirconium and silicon; stabilised zirconia of 97 per cent purity stands up to 2,500° C and molten platinum, rhodium, iridium and tantalum. Then there are those others, gadolinia, samaria, forsterite and ceria—"bits and pieces in various stages of development" being shown at the exhibition: the first two, mixed with alumina, have promise as control rod material in place of boron steel for atomic reactors.

The keyword is purity.

LARGE GRAPHITE BLOCKS

The demands of the American aircraft industry for larger support panels for brazing stainless steel honeycomb have been met by Union Carbide's making graphite blocks up to 110 in



long. Even with the availability of such large sizes joining of several together will be necessary to support current drawing board aircraft designs, with honeycomb panels of 10 ft by 20 ft. Graphite, with its low thermal expansion, has proved to be the only acceptable material for this task.

Union Carbide International Company, and the Carbon Specialities Department most concerned with this project, are at 30 East 42nd Street, New York 17, NY, USA.

KIESELGUHR FOR FILTRATION

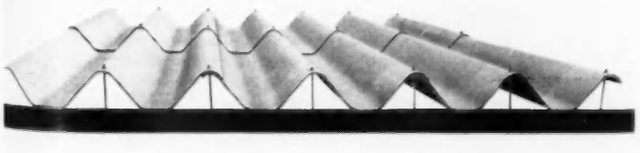
80 Quick and 80 Special are the names given to two new grades of German Kieselguhr distributed by Charles H. Windschuegl Limited, 1 Leadenhall Street, London, EC3. The significance of the quick and special parts of their titles is probably best illustrated by the table below, which shows comparison with existing grades regarding the speed of filtering a suspension of rouge.

80 S. Standard	51·5 seconds
80 S.B.	48 "
80 Super	48 "
80 S. New	42·5 "
80 Special	39 "
70 S. New	35 "
80 Quick	28 "

80 Special is made up of selected diatoms within the size range 30 to 90 microns. It is chemically inert and has been primarily devised for brewing where it gives good clarification. This grade is described as of "good white colour"; not so 80 Quick, which is described as "slightly off-white," but allows fast filtration without build-up of back pressure.

Recent revision of process methods has improved the colour and bulk density of the five other grades which are included in the table and which were first introduced two years ago.

ASBESTOS CEMENT SHEET WITH LARGER SPAN



Does asbestos cement mean architecturally dull?—some might say so. Certainly on the Continent exciting shapes are said to be made which give architects the means to "enjoy themselves more." Two developments are of interest in the United Kingdom—for the bold design and the special. For boldness there is a roof sheeting which is capable of spanning purlins at up to 9 ft 6 in centres. Made by the Universal Asbestos Manufacturing Company Limited, Watford, Hertfordshire, the new sheet has a deep section shown in the illustration. The corrugations are 7 in deep and 18 in apart, in sheet of 3 in thickness.

Magnum sheets, as they are called, are made in lengths of 4 ft to 10 ft by 6 in increments. A minimum end lap of 6 in is recommended by the makers, for which a cellular butyl rubber sealing strip is supplied.

For the unorthodox and special, this company offer to make any reasonable section, though the time required is a minimum of 10 weeks. They have already made jambs and junctions, copings, sills and corners to new designs.

DU PONT ELASTOMERS EXPAND THEIR FACILITIES

Hemel Hempstead Laboratories and Londonderry Production

"Come rain and hail"—may be the wishes of an operator at the new elastomers research laboratory of Du Pont; not, however, for neighbouring Hemel Hempstead, but for the inside of a weatherometer—one of many machines installed for development work on neoprene, Hypalon and Viton by the United Kingdom branch of this American company. This particular machine will duplicate almost any type of condition from intermittent rain and high humidity, to dry or humid sunshine, and will be used to test the weathering of rubbers under accelerated conditions for the engineering, building shipping industries which make use of rubber products out of doors. "Let the elements do their worst," may be effected at the turn of a knob.

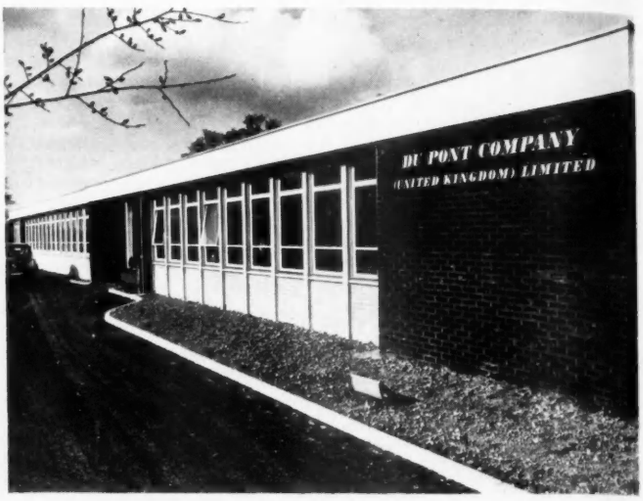
This laboratory is the first permanent facility to be completed for Du Pont in Europe and will be staffed entirely by British graduates and technicians following the company's belief that "there are great opportunities for local citizens to rise to top managerial posts in our (Du Pont's) overseas companies."

The United Kingdom branch of the company has a neoprene plant nearing completion in Londonderry, Northern Ireland, "Increasing use of Du Pont's elastomers," say the company, "makes the laboratory a necessary service to the rubber industry." It is expected that the need for this service will increase materially when the Northern Ireland plant is in full production.

The Hemel Hempstead laboratory is equipped with instruments and testing devices from the United Kingdom, Germany, France and the United States. The equipment can accurately duplicate most of the processes used by rubber manufacturers throughout the world.

The 10,000 sq. ft laboratory will be used to provide technical assistance to rubber manufacturers and processors in Europe, Africa, Australasia, and parts of Asia. It is designed to handle problems relating to the use of rubber products in such industries as building, engineering, motor, cable, railway, paint, shipping, aircraft, and mining.

The laboratory is divided into three main parts: dry processing, fluid processing, and physical testing. In the dry processing area where solid rubber compounds are processed, one of the most unusual pieces of equipment is a high-pressure wire vulcanising unit. This unit simulates continuous vulcanisation conditions used in the wire and cable industry. It consists of a steam chamber for vulcanising at steam pressures of 100 to 275 lb per sq. in and a water chamber for cooling at the same pressures. Before the vulcanisation step, an extruder covers the wire samples with compounds of neoprene or Hypalon synthetic rubber. This machine also can extrude items for use in many industries including sealant strips for the building industry and variously sized hose for the motor industry.



Parallel to the drying processing area of the laboratory is the section devoted to the processing of fluid elastomers such as those based on latex or solutions of rubber in solvents. This area is equipped with an ultrasonic homogeniser and a high speed ball mill. Both machines are used for grinding the components used in rubber latex materials. The high-speed ball mill processes materials in one-tenth the time required by conventional machines. Equipment of this type is used by latex goods fabricators, paint and coating manufacturers, and the foam rubber industry.

The physical testing area is equipped with an extremely accurate and complex electronic load-measuring tester as well as one of the latest types of weatherometers developed in Germany. The load-measuring equipment can be used to measure virtually any of the physical properties of rubber such as stress and strain characteristics, tear resistance, tensile strength and adhesion. It operates at temperatures from − 70 to 550° F.

The physical testing area includes a salt-spray cabinet for problems relating to the use of maintenance coatings of neoprene and Hypalon synthetic rubber for the shipping industry and other industrial users. A high voltage tester for determining the break-down strength of wire and cable insulation, heat aging ovens, flexometers, a Royal Aircraft Establishment freeze tester, a machine for testing the cracking resistance of neoprene compounds developed for shoe soles, abrasion and hardness testers, and an ozone cabinet are among the other items of equipment.

The elastomers laboratory has presently the air of being underworked—but when the programmes on development of production processes, and applications research, and on technical service to the customer are all under way, Du Pont Company (United Kingdom) Limited should have plenty to keep themselves busy. They certainly look forward to that day.

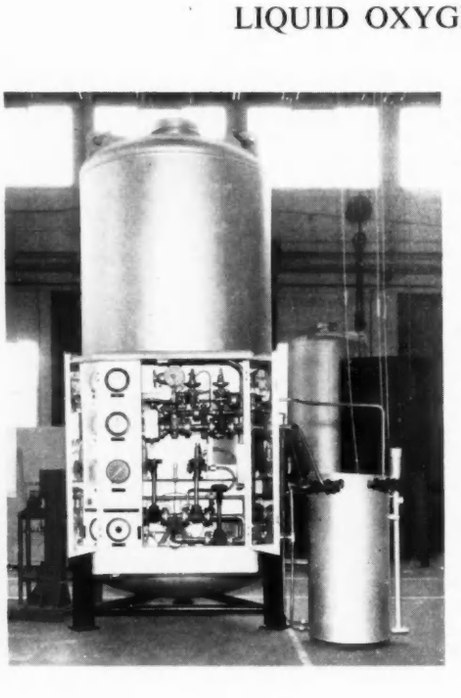
CATALYTIC COMBUSTION OF EXHAUST GASES

A practical and economic method of eliminating carbon monoxide and hydrocarbons from exhaust gases is their complete catalytic combustion to carbon dioxide and water. Research work at the Geneva International Division of the Battelle Memorial Institute has centred around the suitability of the oxides of cobalt as the catalyst for this process. Other workers have tried platinum and vanadium pentoxide, but both, especially the former, have proved to lose activity as the result of poisoning from lead compounds.

The demands on a catalyst in these applications is that the conversion rate should be high at a low ignition temperature, and that it should not be poisoned. Several catalysts were tried in the Battelle work, cobalt monoxide—CoO, the oxide with 4 per cent lithium oxide, and the oxide on asbestos; cobalt oxide Co_3O_4 with lithium oxide, on asbestos and on alumina; and vanadium pentoxide. These workers conclude that cobalt oxides offer good prospects as materials for catalytic afterburners for motor exhaust fumes. As presently developed, they show a conversion efficiency of almost 100 per cent of organic material and carbon monoxide to carbon dioxide and water for approximately 100 hours before having to be renewed. In a passenger car, replacement of the catalyst would therefore be necessary every 1,500 to 3,000 miles.

LIQUID OXYGEN

Storage for the Large and Small User



The two latest developments in storage of liquid oxygen cater for both the small and the large consumer. Model LC3, made by British Oxygen Gases Limited, Spencer House, St. James's Place, London, SW1, will hold 2,900 cu. ft of oxygen and will supply gas at the rate of 300 cu. ft per hour at a pressure of 85 lb per sq. in. It consists of a single cylinder which is vacuum insulated, and incorporates a vaporising unit so that oxygen is drawn off as gas.

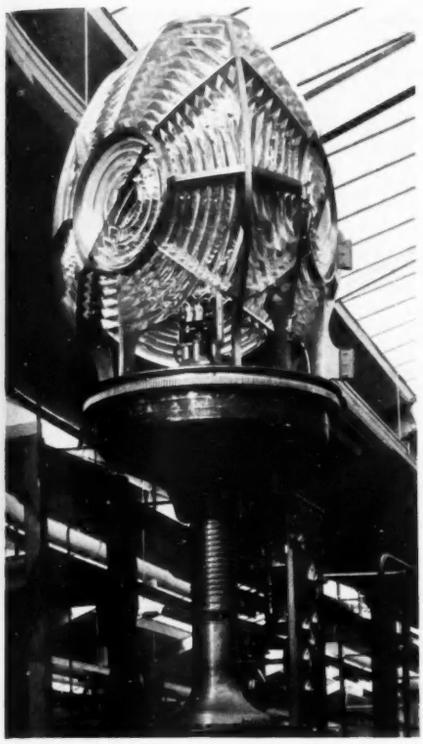
The Coval, by the same makers, is designed for outdoor operation to receive liquid oxygen from transport vehicles, and to convert this liquid to gas at a predetermined automatically controlled pressure. Its effective capacity is 125,000 cu. ft of oxygen, and it will supply gas at a steady rate of 30,000 cu. ft per hour at a maximum pressure of 230 lb per sq. in. In this unit, the liquid is contained in a vertical stainless steel cylinder, mounted inside another cylinder of mild steel. The inner and outer cylinders are separated by insulating blocks, and the annular space between them is filled with a powder insulant and evacuated.

A high-pressure vaporising unit used in conjunction with the Coval is illustrated; it contains a hot water tank heated by electrical immersion heaters or steam.

LIGHTHOUSE EQUIPMENT

Complete installations for the Jakhau and Jegri lighthouses, off the west coast of India, near to the border with Pakistan, have been made recently by Stone-Chance Limited, of 28 St. James's Square, London, SW1. The lighthouses are being modernised.

The equipment is basically similar in both cases. The optic is revolved by a weight-clock



mechanism on a mercury float pedestal and housed in a glazed cast-iron lantern with a copper roofing. The light sources are 100 volt lamps and lamp exchangers are fitted to bring stand-by lamps into focus in 1½ seconds if the main lamp should fail. Since no mains power is available at either site, Stone-Chance have also supplied triplicate generating plant for both lighthouses. Each plant consists of three diesel-engine alternator sets, the second and third being stand-bys for the first. Two control cubicles are provided, one in the engine room and the other in the lantern; these cubicles are insect proof and have been, according to the makers, fully " tropicalised."

Jakhau will transmit a single flash of 2,260,000 candelas intensity every 10 sec and Jegri a group of two flashes every 20 sec, the beam intensity being 1,670,000 candelas. In both cases oil-mantle burners are available as emergency illumination. Automatic operation and the need for little maintenance are two features aimed at in the design.

CHAIR FOR OFFICE COMFORT

Recommendations have been issued by the British Standards Institution for an " ideal " office chair that, though non-adjustable, would suit 80 to 90 per cent of men office workers and more than 50 per cent of the women. The Council of Industrial Design have had a chair suitable for clerical staff designed to meet the BSI recommendations.

The height of the chair is 17 in from the ground (18 in is at present the most common height), the table height of the desk to go with the chair 28 in and the leg room from the floor to the underside of the desk should be 26 in—this is almost always less than 25 in. With the aid of a 1 in footpad the shorter man and most of the women could also then be accommodated; some difficulty may occur with those who are over 6 ft 2 in in height.

The prototype chair has been designed for the medium-price range. It will enable the average person to sit with the small of the back supported, the feet flat on the floor and with the knees at right angles, and with little or no pressure under the thighs from the edge of the seat. As is recommended, the seat is upholstered but not soft; the top of the desk should be at elbow level to avoid hunching of the shoulders, and there should be ample room under the desk for the knees when at right angles. The chair has a fairly wide seat to give the sitter the opportunity to change position frequently.

The prototype chair, upholstered in peacock blue, is being exhibited in an office setting with a pedestal desk of the recommended dimensions, at the Design Centre, Haymarket, London, SW1, until 6 June. It is hoped that such a chair will provide comfort throughout the duration of an office day.

UNIVERSAL GRID MATCHING SLOTTED ANGLE

The range of work possible with Dexion slotted angle has been extended by the introduction of a multi-purpose grid, made in 16 gauge mild steel. The grid is at present available in 9 in width and two lengths only, 4 ft 6 in and 6 ft, though non-standard lengths (in steps of 1½ in) can be supplied for minimum orders of 12 units.

Along with other Dexion products, the grids will be displayed at the building exhibition the company are holding at Stonebridge Park, Wembley, from 26 May to 4 June. Dexion Limited have their main address at Maygrove Road, Kilburn, NW6.

RELIEF VALVES FOR POWER CIRCUITS

There is an urgent need for basic data on the design of relief valves used in power circuits. The main requirements of such valves are that they shall open at a predetermined pressure; that they shall open in as short a time as possible; that opening shall not impose shock loads on the circuit; and that the valves, when open, shall not oscillate and cause noise. In addition the valve must not be so heavily damped that there is a significant time lag before it opens.

(Several of these characteristics are met by the overspeed trip for reciprocating engines that has an instantaneous cut-off described by Mr. R. Malpas and Mr. O. P. Woodroffe, of ICI, Billingham, on page 508 of our issue of 17 April.)

An investigation at the Mechanical Engineering Research Laboratory (now the National Research Laboratory) at East Kilbride has shown that the transient pressure characteristics of eight commercial valves have shown that their characteristics varied widely and that none were satisfactory in all respects. It was found that the circuit itself could influence the characteristics.

An electrical analogy has been developed to study the data required and the technique gives a satisfactory indication of the performance of a relief valve in a hydraulic circuit. The results of this work are to be published shortly and they will enable better designs to be made of relief valve which comprises a cylindrical plunger in a close-fitting sleeve but without dashpot damping. The effect of the circuit on such a valve can be predicted using the analogue technique.

GLUEING CARTONS AT DIFFERING SPEEDS

The capacity of high-speed stencil glueing machines depend to great extent on the employment of an efficient speed-variation control. A new machine—the Thermotex, developed by the Lerner Machine Company Limited—will apply latex or thermoplastic adhesives to cardboard carton " flats," enabling packers to make up their own boxes from the " flats " delivered from the makers—thereby cutting costs.

To deal with a variety of adhesives and many different boards—together requiring different rates of application—the machine has to work at many different speeds; humidity also affects the speed required. The control is by a Sextet auto-manual variable-speed pulley comprising a manual pulley, driving belt and an automatic driven pulley, and made by Industrial Drives Limited of Ealing. The unit is mounted directly on the motor spindle of the Thermotex and gives the motor an infinitely variable-speed drive up to a ratio of 3·6 to 1.

FOUR-WAY VALVE FOR HYDRAULIC RAM

A new range of pneumatically-operated four-way valves for the control of double-acting hydraulic rams, which eliminate the need for two three-way valves of conventional pattern, are being marketed by Hutton and Mitton Limited, Oozells Street North, Birmingham, 1.

These valves, which operate through either a manual pilot or an electric timer, are actuated by a single diaphragm top. This simplification has been made possible by using the line pressure to act against one section of the valve on a differential area principle. A two-way valve fitted in one of the cylinder lines enables the ram to be stopped in any desired position. The design of the valve is such that there cannot be any loss of water to the drain when the disc travels from one seat to another. Skirted seat rings protect the seat surfaces from wire drawing and water hammer effects in the valve are eliminated by V slots in both the inlet and seating rings of the valve.

The valves are suitable for hydraulic working pressures from 200 to 3,000 lb per sq. in at temperatures up to 140° F and are made in sizes of ¾ in, 1 in, 1½ in and 2 in.

NUCLEAR REACTOR CONTROLS

By J. Walker, M.A., A.M.I.E.E.

The choice of control variable for different types of reactor and methods of providing control are discussed. An outline is given of the scope and range of instrumentation necessary to provide adequate safety. The article was originally presented as a paper to Section G of the British Association at their Glasgow meeting in 1958.

THE basic requirements for the control system of a nuclear reactor and its associated power plant are not very different from those for conventional process plants and mechanism control systems. Appropriate variables must be measured, compared with their desired values, and any discrepancies used to actuate devices which will bring these variables to their proper values. The human operator may or may not be included in this chain of events, depending on the complexity of the system.

The chief differences of the reactor from other control problems are in the novelty of variables to be measured, the inherent control response of the reactor itself, and in the possible seriousness of any accident to the reactor. While this last point is one of safety rather than control, it is obvious that the two are very closely related, and safety has a considerable bearing on the choice of control system design, to a much higher degree than is met in general in control systems.

CONTROL VARIABLES

The measurement of most interest to the reactor user will depend on the type of reactor. For the power engineer, this will be the thermal output, but for the nuclear physicist, neutron flux may be more important. The two are, of course, directly related ($3{\cdot}2 \times 10^{-11}$ joules per fission) but show transient discrepancies when the power level of a reactor is changed, e.g., at start up or shut down. This is due to the fact that all of the energy released at fission does not appear instantaneously. Some 6 per cent arises from the radioactive decay of fission products, and some of these have very long half-lives. Moreover, the thermal output can only be estimated by means of temperature measurement, and in a reactor of any size, the thermal capacity of the system will be such as to produce a considerable time lag in temperature change following a change in neutron flux. It is therefore necessary in all reactors to measure neutron flux to obtain a reasonable picture of the reactor state at any instant. This by no means precludes the measurement of temperature as an important feature of an overall control system, particularly at full-load conditions. In certain cases it is very important to ensure that system temperatures shall only change very slowly, to avoid damage to the reactor fuel and pressure vessel; so one would expect to find temperatures a controlling feature in this range. During reactor shut-down, however, and in the early (low-power) stages of start-up, the vastly better response obtainable from nuclear measurement is vital. The details of the techniques of this measurement are well published elsewhere,[1 2 3] and represent a complete technology in their own right. Suffice it to say that what is measured is a sample of the leakage neutron flux from the reactor into its shield.

Apart from being the only rapidly responding reactor variable which can be measured, neutron flux provides a means of assessing the quantity in which the designer is really interested from the point of view of control—the reactivity.

Reactivity is a function of the reproduction constant of the chain reaction, the factor by which neutron population is increasing or decreasing between successive generations of fissions. The reproduction constant depends on the reactor geometry and the fuel used, and is described by either an "infinite" value, K_∞, in which an infinite lattice is assumed with no neutron leakage, or an "effective" value, K_{eff}, which takes into account the neutron leakage present in a finite practical reactor core. The reactivity, ρ, is a function of K_{eff} such that

$$\rho = \frac{K_{eff} - 1}{K_{eff}}.$$

Thus, for ρ negative, K_{eff} is less than 1 and the system is convergent, with successively less neutrons in each succeeding generation. For ρ positive, the system is divergent. In a convergent system, however, the neutron population does not decline to zero, but tends to a constant value at which the convergence is just offset by the injection of "source" neutrons, either from the spontaneous fission of uranium or from artificial neutron sources intentionally placed in the reactor.

The relation between neutron flux and reactivity may be expressed by the relation

$$\frac{dn}{dt} = A\rho n + S \quad . \quad . \quad . \quad (1)$$

or, integrating,

$$n = \left(n_o + \frac{S}{A\rho}\right) e^{A\rho t} - \frac{S}{A\rho} \quad . \quad (2)$$

where n = neutron population,

n_o = neutron population at time $t = 0$,

$$A = \frac{K_\infty}{\text{average neutron lifetime}},$$

ρ = reactivity,

S = rate of injection of "source" neutrons.

With ρ negative it will be seen that $n \longrightarrow \frac{-S}{A\rho}$

and the convergent reactor acts as a neutron multiplier, the multiplication increasing as ρ becomes less negative.

For zero reactivity the reactor is said to be critical and the neutron flux increases linearly with time, but very slowly (10μW per sec in a typical reactor with 6 MW full-power operation). Criticality is sometimes alternatively defined by the constant power state $\frac{dn}{dt} = 0$ or $\rho = \frac{-S}{An}$.

This fine distinction is, however, rather academic, since any measurement of reactivity must be by observation of neutron flux change.

Positive reactivity provides a diverging exponential in which the source term, $\frac{-S}{A\rho}$, is rapidly swamped, and the reactor period, the time for neutron population to change by a factor e, is determined by ρ and A. It has thus far been assumed that an average lifetime can be ascribed to each generation of neutrons, but in practical work it is necessary to take account of the fact that all fission neutrons are not produced at the instant of fission, but some arise from the decay of fission products having half-lives of up to 56 sec. These must be treated separately from the majority of the fission neutrons, the "prompt" neutrons, which in a graphite-moderated reactor have an average lifetime of about 1 millisecond. The delayed neutrons increase this effectively to about 100 milliseconds, which would be the value used in the simple expressions (1) and (2). Reactivity is deduced from an observation of reactor period, which is measured by a time derivative of a logarithmic presentation of neutron flux.

REACTIVITY BALANCE

Before considering the methods by which reactivity can be changed intentionally, it is necessary to consider what reactivity changes can occur in the reactor spontaneously during the course of operation. For a number of reasons, outlined later, the reactor will in general slowly lose reactivity as the chain reaction proceeds; thus, if it is to be kept operating at a given rate, it must of necessity be provided with a core which is initially greater than the minimum critical size. Such a system would of itself be divergent, having a positive reactivity—sometimes called the "gross" or "built-in" reactivity.

For stable operation at constant flux the net reactivity must be kept at zero, and this is achieved by the adjustment of reactivity control devices. The reactivity controllers must have an appropriate margin in hand to enable the reactor to be shut-down as required for operation and to provide a safety factor in the event of a mechanical failure of any of them. The margin must however be kept as small as is safe, since an excessive investment of control reactivity implies an excessive gross reactivity required of the core design, with a resulting increase in fuel investment.

The choice of fuel investment must take account of the normal cycle of operation of the reactor, which will vary very widely between different types. The period over which continuous power operation is essential will be different in the cases of research, power production, and propulsion reactors. Again, the need for part-load operation, implying reactivity control to enable the power level to be changed, will be different in the three applications.

The three most important changes of gross reactivity which occur in the life of one fuel charge are due to temperature, fission-product poisoning, and depletion.

(1) As the reactor is taken from low to operating powers, system temperatures rise, and this affects the reactivity in many ways. To give a few examples:—by changing the proportion of neutrons which at any time are at a particular energy level in the reactor; by altering the number of atoms of fuel and moderator which are present in the system in certain cases; and by producing density changes in coolant gases (where this applies), thereby altering the number of neutron-absorbing atoms in the reactor. These changes are described by "temperature coefficients" for the particular process and may be positive or negative. For operational stability it is preferable that the overall effect be kept negative by appropriate design, as this implies that power increases will result in reactivity decrease and thereby restrict the further increase in power. The reactor temperatures are intimately affected by the extraction of useful power from the system, and it is therefore necessary to consider the reactor power plant as a whole when a control system is designed. The problem of the inter-related effects of thermodynamics and neutron kinetic behaviour is quite involved and calls for the use of the most modern computing techniques for its solution.

(2) Very prominent among the end products of uranium fission are certain atoms, notably Xe 135 and Sm 149, which have very large neutron absorption cross-sections. These compete with the fissile material for the neutrons available to continue the chain reaction, and thus reduce the reactivity. Because of this effect they are known as "poisons." In absorbing neutrons they become changed to atoms of smaller absorbtion cross-section, and Xe 135 also undergoes a natural radioactive decay. The concentration of these poisons under steady operating conditions represents an equilibrium between their production and removal. If the power level of the reactor is changed this equilibrium is disturbed, and several hours must elapse before it is restored. The value of the equilibrium concentration is a function of the neutron flux and has a reactivity value which will be many times greater than the net reactivity changes normally used to alter the reactor power level at a convenient rate in controlled operation. For example, ρ_{Xe} for a reactor with neutron flux 10^{14} n per cm^2 per sec is about -5×10^{-2}. The stable Sm 149 poison accounts for about -1×10^{-2} in reactivity. After shut-down both these poisons build-up since they are no longer being spent in absorbing neutrons, and their production will continue after shut-down until their parent nuclides I 135 and Pm 149 are exhausted. The concentration may rise to very high values ($\rho > -0{\cdot}2$ for Xe), which

may be more reactivity than can be economically built into the reactor core. In this case the reactor will "poison out" after shut-down and it may be necessary to wait up to two days before the xenon has decayed to a level where a net positive reactivity can be applied to the reactor to permit a further divergence to power.

It will be evident from the fact that the xenon is destroyed by the neutron flux that poisoning represents a de-stabilising effect in control, since a positive reactivity will increase flux which will reduce xenon concentration.

In some applications, notably for propulsion, where loss of power is unacceptable, the poor neutron economy of having to provide sufficient built-in reactivity to the core to enable poisoning to be overridden has to be accepted. Under normal conditions this extra gross reactivity is off-set by the continuous application of more effective or more numerous control devices.

(3) Long term changes in reactivity arise from the "burning" of the fissile atoms in the fission chain reaction, which is equivalent to a removal of fuel from the system. In natural uranium this loss of reactivity is offset by the production of new fissile atoms Pu 239, Pu 241 and Pu 242 produced by neutron capture in the uranium. Pu 240 is also produced which absorbs neutrons strongly.[4]

Elementary calculation of burn-up assumes this to occur uniformly throughout the reactor, which is of course not exact, since fluxes will in general be lower at the reactor periphery and in the immediate vicinity of neutron absorbing material. Non-uniform burn-up has a greater effect on reactivity than a uniform one, so that it is preferable that the reactor be designed with control absorbers as far out of the reactor as possible in normal operation, and to achieve efficient use of the fuel it may be necessary to transfer this from one part of the reactor to another as operation proceeds.

In reactors using highly enriched fuels where there is little fertile material present, the working life of a single fuel charge will be limited by the reactivity loss which can be accepted. For example in the high flux research reactor DIDO, 10 per cent of the fissile atoms are destroyed in six to seven weeks of full-power operation, and this has an overall reactivity effect of $\rho = -2{\cdot}75 \times 10^{-2}$. Fuel changing has therefore to be carried out at about this frequency.

REACTIVITY CONTROL METHODS

Reactivity being a function of the effective reproduction constant of the chain reaction, it is controlled by variations in any of the factors which go to make up that constant. This is done in one or more of a number of ways, the choice depending on the type of reactor.

The "classical" method of reactivity control is the movement of some strongly absorbing solid, usually arranged for engineering convenience in the form of a bar or rod. Suitable materials for such rods are boron, cadmium or haffnium. The choice between such materials is usually dictated by cost or straightforward engineering considerations such as melting point and normal working temperature. Boron, when used, is generally in the form of boron carbide, B_4C, or used as an alloying element in steel. This mode of control may also be applied using liquids. Mercury has been suggested in this context. In liquid homogeneous reactors, reactivity could be changed by altering the concentration of absorbers in the system, for example by control of the fission-product extraction plant forming part of such a reactor, though questions of control reliability may render this approach unattractive.

An alternative method of reactivity control, particularly applicable to fast reactors, is by movement of reactor fuel. In such applications the effectiveness of neutron absorbers is much reduced because of the lower absorption cross-section of suitable materials for high energy neutrons. This can in certain cases be sufficiently significant that it becomes difficult to accommodate the increased absorber area within the reactor core. The chief disadvantages of using fuel movement for control are the necessity to arrange for movement of the cooling circuit serving that fuel, and the mechanical difficulties of charging and discharging. On the other hand, as applied to liquid homogeneous systems, fuel movement is conveniently effected by change in concentration of the soluble fuel in the solvent moderator, e.g., auranium salt in heavy water.

Control can also be effected by alteration of the leakage of neutrons from the core. This can be done by changes in core and reflector geometry. The method is again particularly applicable to fast reactors. Thus, for example, the low-energy fast reactor ZEPHYR is controlled by the movement of material from the reflector or blanket, creating voids which increase the neutron leakage and reduce the reactivity.

Finally, and of very great importance in nuclear power plant control, it is possible to change plant conditions so as to change the reactivity through the medium of the inherent reactivity changes, particularly temperature. For example, in a homogeneous reactor with constant circulation rate an increase in the power extracted will tend to reduce system temperatures, which, with a negative temperature coefficient, will increase the reactivity, making the reactor power diverge until the original temperature has been restored. Similarly, with systems such as at Calder Hall, an increase in coolant blower speed produces a like effect, this time under constant temperature conditions.

RATE OF REACTIVITY CONTROL

It is not possible to quote a specific rate of reactivity addition which should not be exceeded, except in reference to a particular design. In addition it is also necessary, before choosing a control rate, to study the possible effects of its application in conjunction with possible breakdown of various parts of the plant, e.g., failure of main coolers or a failure of the control mechanisms themselves in which their movement could not be arrested. In such a design study, the worst possible conditions must be postulated, and, for a given control rate, the reactor shown to be safe and operable. The decision as to what represents the "maximum credible accident" is invariably difficult. It is obviously not acceptable to experiment with an actual reactor under such conditions, and once again it is necessary to call in the assistance of theory, backed up by computational aids. It is, however, possible to learn a very great deal about the fundamental response of a reactor by studying the power response to cyclic perturbations of reactivity. These can be arranged to be of such a magnitude and frequency that the modulation of the reactor power can be kept within reasonable bounds—say $\pm$ 10 per cent—and to arrange that any excess of this would cause the reactor to shut down.

RANGE OF MEASUREMENT

In considering the safety of a nuclear reactor it is necessary to take account of all possible failures of equipment, including the control system. The significance of such a control failure will depend on the state of the reactor at the time, but would obviously be most serious in the shut-down condition when, with a cold, unpoisoned reactor, the system would have its greatest potentially available reactivity. It is therefore most important to know the neutron flux at all times. This leads to a requirement in the instrumentation which is peculiar to this field, namely to provide instruments which, while capable of registering perhaps hundreds of megawatts, can still provide sensitive information when powers are in the milliwatt range. The use of a logarithmic presentation reduces considerably the number of instruments required. On the other hand, the combined need for reliability and freedom from unwanted shut-down requires that each reactor safeguard should be instrumented in triplicate, and it is quite usual to find a dozen or more neutron-flux monitoring channels in a typical installation.

The siting of the detectors for these channels presents considerable difficulty. They must be placed in a position where they will give a good output current and yet not be in such a high flux that they deteriorate rapidly by radiation damage. They must be placed in a position where good discrimination can be obtained between neutron flux and reactor γ radiation. This requires that they be kept away from reactor structural material such as steel which will remain γ-active after the reactor has shut down. They should be placed in a position of low-flux gradient, so that slight changes in their positioning after replacement or differences in effective centre of different detectors do not seriously affect their calibration. They must be so sited that the sample of neutron flux which they "see" is always representative of the total fission rate of the reactor, and is not seriously affected by perturbations in flux distribution by movement of the control rods. They must also be able to withstand the physical conditions of their location for considerable periods without frequent attention.

OTHER REQUIREMENTS

As reactor control has been discussed, the particular measurement pertinent to control, namely neutron flux, has been emphasised. It would however give a very false picture of instrument requirements if nothing were said about other parts of the equipment, which may indeed outnumber the neutron flux detection channels very heavily. In any reactor power plant, a very expensive and complex piece of machinery is being considered, and it is of very great importance that the many variables in the system should be observed. Among the foremost of these are fuel temperatures; coolant temperatures, pressures, and flows; moderator temperatures; and radioactivity in the various parts of the plant, particularly the cooling circuits and the working spaces around the reactor. In liquid moderated reactors, having a variable moderator depth, e.g., DIMPLE and NRX, the liquid level becomes a control variable and must be accurately measured. Consideration has to be given to corrosion effects and measurements of pH and conductivity are required at appropriate parts of the plant.

Of particular interest among the activity measurements are the measures taken to detect defective fuel element sheaths. These sheaths are provided to retain the highly radioactive fission products, and failure of the sheath results in these fission products being dispersed through the cooling system. This presents a difficulty in the proper maintenance and repair of the plant where coolant is recirculated, and a more serious and widespread problem if the coolant is "once-through." The major problems in detection are the discrimination between fission-product activity and activity from other sources, and the provision of a sufficiently rapid scan of a large number of fuel elements.

PROTECTION CIRCUITS

Just as it is impossible to divorce control from instrumentation, it is equally necessary to consider control and safety conjointly. Control devices are frequently designed to be operable as safety devices also, and the initiation of this mode of operation under reactor-fault conditions has to be made automatic and as fool-proof as is humanly possible. This calls for reliability, not only in the measuring instruments and in the control or safety mechanisms but also in the protection circuits which translate the information provided by the one into the action taken by the other. The techniques used in the research reactors of the United Kingdom are described in some detail elsewhere,[5] but it should be remembered that different types of reactor, or even different reactor location, may make other methods preferable. In this country very great use is made of the Post Office telephone relay as a logical element in start up and safety circuits. Designs for this country take no account of the possible prejudice to safety resulting, for example, from earthquake damage—quite a serious consideration in some parts of the world.

The age of the mobile nuclear power plant is near, and such equipment, having moving parts, may appear at a disadvantage. It may no longer

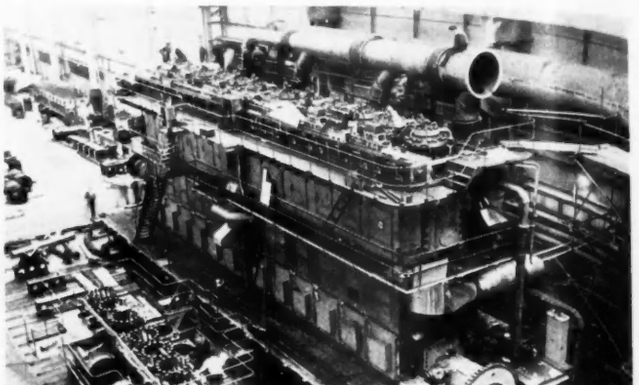
SCAVENGING AND COOLING A 15,400 HP MARINE DIESEL

The most powerful turbocharged engine yet built in the United Kingdom—it has a rating of 15,400 b.h.p., but is intended for continuous operation at 14,000 b.h.p.—has been tested by the builders, Alexander Stephen and Sons Limited, Glasgow. It is a Sulzer RSAD76 engine, designed for operating on boiler fuel and it is to be fitted in the Ellerman ship City of Melbourne.

The engine is of the two-stroke type and has cast-iron cylinder liners. The admission of the air is controlled by the top edge of the main pistons. To retain sufficient air in the cylinders for combustion the exhaust ports are closed by valves at the end of the scavenging process before the pistons close the scavenge ports. The exhaust valves are of the semi-rotary type and are operated by levers from the camshaft. The scavenge air is collected in a scavenge receiver which obtains its supply from four Sulzer turbo-blowers. The undersides of the pistons act as scavenge pumps and, at slow running when manoeuvring, this assistance from the underside of the pistons is of considerable value. Experience with the design has shown that it is not necessary for scavenge pumps to be fitted and low speed running is achieved with a clear exhaust.

The turbo-blowers each have a turbine wheel and a blower impeller on one shaft. Each blower unit is supplied with exhaust gas by separate pipes from three cylinders. When the engine is installed the gas leaving the turbines will be led to a waste heat boiler to generate steam for ship's services. About 4,200 lb of steam per hour at 100 lb per sq. in will be produced at normal service power.

Fuel is supplied by a booster pump at 25 lb per sq. in to the fuel pumps which deliver timed and measured quantities of fuel at high pressure into the cylinders through injectors. Separate pump elements are provided for each cylinder and pairs of these are contained in blocks situated on the camshaft casing. The pump plunger at each element is driven by a fuel cam through a roller. The regulating shafts are connected to a variable-speed governor which controls the quantity of fuel injected by operating on the fuel pump suction and spill valves. The arrangement of rods makes it possible to modify the valve openings so that the ignition can be changed while the engine is running.



Twelve cylinder Stephen-Sulzer diesel, turbo-charged to operate continuously at 14,000 b.h.p. It is the largest engine of its type to be tested in the United Kingdom.

The same fuel cam is used for both ahead and astern running, its shape being symmetrical. When reversing, the camshaft is moved by the servo-motor 60° towards the new direction of rotation. Provision is made for heating the fuel pipes so that boiler oil can be burned in the engine.

The cylinder and body of the exhaust valves are cooled by fresh water from the same header, and the fuel valves by fresh water from a separate circulating pump. Cooling of the piston is by oil supplied through a swing linkage to the crosshead and thence through an annular space formed by the bore of the piston rod and the return pipe within it. The guide bar cooling is by oil supplied from the main bearing lubrication system. Only the ahead guides are cooled. The engine will also be stopped automatically in the event of the failure of the lubricating and cooling oil supply or of the cooling water supply.

The bedplate and columns are of fabricated steel. The tensile stresses are taken up by long tie rods which extend from the bottom of the bedplate to cylinder tops.

Concluding

Nuclear Reactor Controls

be possible to use gravity as the single actuating force for our safety devices; and hydraulic systems, which we now tend to avoid because of their greater complexity, may have to be used. New techniques in logical circuits, using transistors and ferrite cores instead of relays, are also receiving a great deal of earnest attention.

CONCLUSION

The control of nuclear reactors is a continuously expanding technology still very much in its youth. Present-day practice makes that of only a few years ago appear unbelievably naïve, and there can be no doubt that within a similar short span the same will be said of what is done to-day. And, finally, absorbing though the problems are, control engineers must occasionally remember that theirs is only one aspect of the overall reactor design, and sight must never be lost of the ultimate objective of the reactor, whether it be to produce industrial power or a source of neutrons for nuclear physics research.

REFERENCES

[1] W. Abson and F. Wade, "Nuclear Reactor Control Ionisation Chambers." *Proc. I.E.E.*, Paper No. 2029M, vol. 104, part II (March 1956).

[2] D. Taylor and J. Sharpe, "Nuclear Particle and Radiation Detectors." *Proc. I.E.E.*, Paper No. 1022M, vol. 98, part II, p. 196 (July 1950).

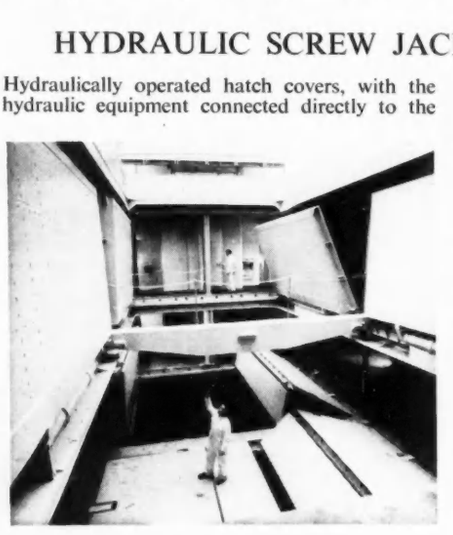
[3] R. J. Cox, A. B. Gillespie and W. Abson, "Neutron Flux Instrumentation Systems for Reactor Safety and Control." Paper A/Conf 8/P/434, International Conference on the Peaceful Uses of Atomic Energy, 1955.

[4] R. V. Moore, "The Control of a Thermal Neutron Reactor." *Proc. I.E.E.*, Paper No. 1431M, vol. 100, part I, p. 90 (December 1952).

[5] A. B. Gillespie, "The Control and Instrumentation of a Nuclear Reactor." *Proc. I.E.E.*, Paper No. 2058M, vol 104, part II (March 1956).

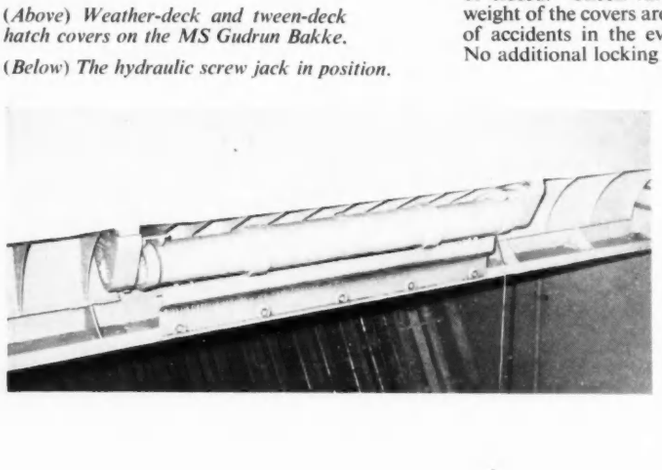
HYDRAULIC SCREW JACKS FOR SHIPS HATCHES

Hydraulically operated hatch covers, with the hydraulic equipment connected directly to the hinges of the covers, have been fitted on the Norwegian cargo liner MS Gudrun Bakke, of 10,500 tons deadweight. The vessel was built by AB Götaverken for the Knutsen Line of Haugesund.



(*Above*) *Weather-deck and tween-deck hatch covers on the MS Gudrun Bakke.*

(*Below*) *The hydraulic screw jack in position.*



The Gudrun Bakke has both weather deck and tween-deck covers of the new type, which are of pontoon form, completely covered with steel plates on both sides. When closed the hatch covers lie flush with the decks so that fork-lift trucks can be run over them. Altogether, there are 22 covers in the vessel made up of 76 sections and 62 of the sections are raised and lowered by the new hydraulic screw jacks in less than one minute. The remaining 14 sections are operated by telescopic jacks of the lever type.

The hydraulic screw jack is of a very simple construction and each has two working cylinders connected to a piping system which is branched to several associated hatches. Oil under pressure is directed into one or other of the cylinders according to whether the hatches are to be opened or closed. Check valves to compensate for the weight of the covers are fitted to eliminate the risk of accidents in the event of a pipeline fracture. No additional locking arrangements are fitted.

The jacks develop a torque of 20 ft-tons at a top oil pressure of 1,400 lb per sq. in and allow a 90° angle of rotation. Götaverken are able, however, to make heavier jacks giving torques up to 100 ft-tons operating through an angle of either 90° or 180°. Control for several hatches can be arranged on one panel and pumps act as standbys for each other.

DIESEL LOCOMOTIVE OPERATION

Overhaul of diesel locomotive for railcar engines when the engine service counter reads 9,000 hr is recommended by the Railway Traction Department of Rolls-Royce Limited.

On shunting duties these 9,000 engine service hours are equivalent to about 16,500 shift hours, during which a locomotive would have a driver allocated to it, or about 13,750 hours if deductions are made for meal breaks and light running to and from the sheds. In railcars on ordinary service with maximum speeds of up to 70 m.p.h. and gradients of up to 1 in 50, the 9,000 hr are equivalent to 250,000 miles. Engines can be left working longer than the period specified, but for a satisfactory life without unexpected breakdowns, 9,000 hr is the recommended limit.

Normal attention is required during the 9,000 hr period, but this limited to top decarbonising at 3,000 hr, changing the injectors at 1,200 hr and periodical replenishment of oil and cleaning of filters. All this can be done without removing the engine from the locomotive or railcar.

To give this life between overhauls of 9,000 engine service counter hours, Rolls-Royce diesel engines for railway traction work are adjusted to give power outputs well below those at which engines are supplied for automotive and other less arduous duties. The power ratings, for 85° F and 500 ft above sea level, are given in the graphs alongside.

EFFECT OF ADVERSE CONDITIONS

Increases in temperature, humidity or altitude decrease the weight of air drawn in by the engine This would normally have the effect of producing an over-rich combustion mixture, reducing the power and raising the thermal stresses. A commensurate adjustment is made at the factory, however, by adjusting the engine to the conditions foreseen. This further affects the power output, and the total h.p. reductions for different conditions are:

1. Naturally aspirated (C4N, C6N and C8N) or supercharged (C4S, C6S and C8S) engines:

(*a*) Air inlet temperature: deduct 2 per cent for each 10° F (5·6° C) above 85° F (29·4° C)

(*b*) Altitude: deduct an additional 3·5 per cent for each 1,000 ft (305 m) above 500 ft (152·5 m)

2. Turbocharged (C6T and C8T) engines:

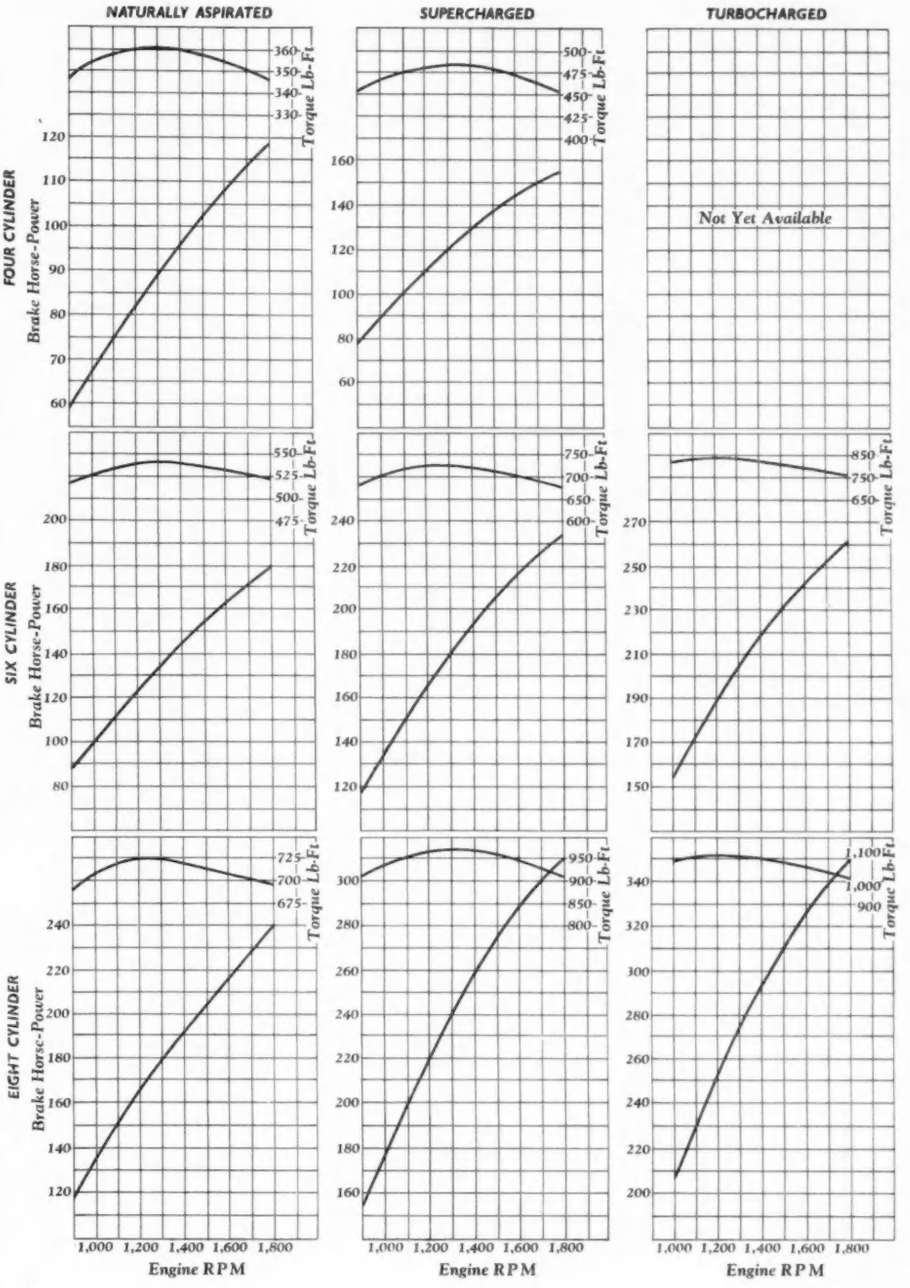
(*a*) Air inlet temperature: deduct 3 per cent for each 10° F (5·6° C) above 85° F (29·4° C)

(*b*) Altitude: deduct an additional 0·7 per cent for each 1,000 ft (305 m) above 500 ft (152·5 m).

The reduction for turbocharged engines at altitude is less because the turbocharger is not coupled mechanically to the engine, and it can therefore speed up when the air is less dense. It follows that turbocharged engines are particularly suitable for use at high altitudes.

Further deductions must be made for humidity, as shown in the following tables; more than 6 per cent reduction is rarely justified by conditions anywhere.

It is usually unnecessary to make deductions for both the maximum altitude and the maximum temperature together, because the highest temperatures usually occur only in the lowlands. An engine that has been adjusted for the worst conditions foreseen can still be used at 85° F and 500 ft. The power will then be found to be reduced by only half the amount of the reduction to be expected under the worst conditions.



Percentage Reduction of Power for Atmospheric Humidity at Various Temperatures

Ambient temperature, °F	Percentage humidity									
	10	20	30	40	50	60	70	80	90	100
85						0·5	1·0	1·5	2·0	2·4
90					0·4	1·0	1·6	2·2	2·7	3·3
95				0·2	0·9	1·6	2·2	2·9	3·6	4·2
100				0·7	1·5	2·2	3·0	3·8	4·6	5·3
105			0·3	1·2	2·1	3·0	3·9	4·8	5·7	6·6
110			0·7	1·8	2·8	3·8	4·9	5·9	6·9	8·0
115			1·2	2·4	3·6	4·8	6·0	7·2	8·4	9·6
120		0·4	1·7	3·1	4·5	5·9	7·3	8·6	10·0	11·4
125		0·8	2·3	3·9	5·5	7·1	8·7	10·2	11·8	13·4

Ambient temperature, °C	Percentage humidity									
	10	20	30	40	50	60	70	80	90	100
30					0·1	0·6	1·2	1·7	2·2	2·7
32					0·4	1·0	1·6	2·1	2·7	3·3
34				0·1	0·8	1·4	2·1	2·7	3·3	4·0
36				0·4	1·2	1·9	2·6	3·3	4·0	4·7
38				0·8	1·6	2·4	3·1	3·9	4·7	5·5
40			0·2	1·1	2·0	2·9	3·8	4·7	5·5	6·4
42			0·5	1·5	2·5	3·5	4·5	5·4	6·4	7·4
44			0·9	2·0	3·0	4·1	5·2	6·3	7·4	8·5
46			1·2	2·4	3·6	4·8	6·0	7·3	8·5	9·7
48		0·3	1·6	2·9	4·3	5·6	7·0	8·3	9·6	11·0
50		0·6	2·0	3·5	5·0	6·5	7·9	9·4	10·9	12·4
52		0·9	2·5	4·1	5·8	7·4	9·0	10·6	12·3	13·9

PRINTING FACTORY
with Optimum Loading

The factory is designed for flowline production, the process starting in the composing room—to be seen in the background.

Operations research can be applied to printing. Planned optimum loading of printing machines can be achieved by linear programming, in a similar way to the use of the technique for machine tool loading; and the techniques of stock control, etc., can also be applied. At the new factory of Perivan Group Limited, Eastwood, Essex, this procedure has been followed. The building has been built around the process, which has been rationalised on the flowline principle.

About 11 layouts of plant were studied by engineers from the Works Study School, Cranfield, in cooperation with Perivan executives, before the final one was selected. One result has been the reduction of materials handling by 32 per cent. However, Mr. I. E. Heath, managing director, believes that although the new factory is one of the most efficient in Britain, there is room for further development. Mr. R. C. Norbury of the Works Study School agreed. "We think we have been reasonably rigorous in the analysis of this problem, but it would be quite false to suggest that we have reached the limit; it will be interesting to see in the next three years the further development that takes place."

The factory stands on a 1·3 acre site. It was built by the Rose Construction Company Limited and has a total area of 14,000 sq. ft; the production area is 10,000 sq. ft. All office accommodation is situated along the front of the factory. The open central production area measures about 123 ft by 70 ft and has a single span roof with four north-light bays. The building is of brick. In the main production area a 1·5 in granolithic floor has been laid *in-situ* on a 6 in concrete sub-floor reinforced with No. 65 BRC fabric and laid on 6 in consolidated hardcore.

The use of a single span roof has enabled the production area to be free from obstruction by pillars and partitions. Every department of the printing process is situated there: the composing room (containing the Monotype department and the pre-makeready department), the letterpress machine room, litho machine room, finishing room, and warehouse. The paper store runs parallel with the flow of work, along one wall, and as can be seen from the illustration.

This feature, together with the use of wide gangways, minimises transporation and enables a constant supply of paper to be maintained for the machines. Paper from a centrally sited store is fed to the machine room by means of the main gangway, while pre-cut paper is stored in the area bordering the gangway.

The flow of work is in a direct line. Each job starts at one end of the building—in the composing room—and finishes at the other end, in the despatch department. Two members of the production staff have qualified as work study engineers, to ensure the smooth running of the system.

The Monotype casting room has been partitioned off from the main area, to provide some degree of soundproofing. It has an average output of 8,000 to 9,000 ens per hour. The pre-makeready department contains a Vandercook proof press, a plate gauge, and a block leveller; it is claimed that an accuracy of 0·0005 in is maintained.

The company say that this department plays a vital part in the smooth running of their system, reducing machine standing time to a minimum. There are also facilities for producing metal mounted blocks, Primaton plastic overlays, together with saw, drill, etc.

In the letterpress machine department there are 13 automatic presses ranging up to double-demy, of which eight are Heidelbergs. There are three presses in the litho machine room, and a two-colour double-demy is likely to be installed shortly. Among the plant in the finishing department are two powered guillotines, and a range of Camco equipment.

A relative humidity of 55 per cent is maintained in the production area, to prevent such faults as chalking and variations in the condition of the paper. Warm air is distributed through high-level trunking to the factory area, and humidification is carried out by water sprays inside the trunking. Air heating is carried out by an oil-fired heater, operating on 32-45 sec oil, the heat exchanger being of chrome-bearing cast iron tubes.

BUILDING ON WORK STUDY
Ice Cream Factory Designed from the Inside Out

With unlimited scope to use any shape and any approach, how do you set about building a factory for ice cream production? What shape? What size? How many storeys? How will it expand? These and other questions are answered in a paper "The Search for Productivity in a Food Industry," by Mark Bogod. The author, a director of J. Lyons and Company Limited, describes how the ice cream factory at Bridge Park was designed "inside out." The paper was presented to the Institution of Production Engineers.

Forty acres of land were available at the site chosen. However, the first stage of the new factory was not likely to require more than 1·5 acres, or, with access roads, despatch yards, and engineering services, a total of 5 acres. Planning was undertaken by a development team using work study principles. Such a team, comprising mechanical, electrical, and refrigeration engineers, a chemist, a planning engineer, and operational managers (people concerned with the production and distribution of ice cream), had successfully developed improved production methods at the company's main factory at Cadby Hall; and it was felt that a similar team approach was ideally suited to the design of the new factory.

The direction of expansion in the new factory was of considerable significance, as the building had to be capable of expanding, first of all, to double its initial size—merely to complete the transfer of equipment from Cadby Hall—and subsequently by an unlimited amount in order to take care of future growth. It was desirable for goods to flow in a constant direction through the factory; and it was essential for them to end up in a cold store. The shape meeting these requirements was a rectangle, in which the production flowed in parallel lines across its width (South to North), with the cold store along the northern wall; expansion could take place along the length of the rectangle—westward. A single direction for expansion was fixed by the building being as near as possible to the main road past the site. Factory width, about 150 ft, was such as to accommodate the largest plant, Choc Ice. Smaller plant, initially installed, left space at either end for administration services and mixing plant.

A large part of the capital cost of an ice cream factory is bound up with the refrigeration engine room, the refrigeration pipes, and the heavy electrical installations. As the engine room had to expand with the factory, there was only one possible position suitable for it—on the south side of the rectangle. Only one position, that is, if a single storey factory were built. And right up to the preparation of the detailed drawings this conception was adhered to. At this point, however, it was found that it was possible to locate the engine room under the production floor, using a two-storey building. This arrangement had been repeatedly considered, as it gave a most economic layout; it had been rejected because the upper floor, which was subject to repeated washing down, would have to be pierced by hundreds of service pipes, which was thought impracticable. When a method of doing this was discovered, the detailed plans of the single storey building were scrapped.

On the upper production floor, tiles were laid with falls to drains, a waterproof membrane being inserted between the tiles and the floor. In each place where a service pipe was required, a stainless steel sleeve was inserted, concrete and the waterproof membrane being lapped up the side of the sleeve above the level of the floor. This practice made it essential to locate each piece of plant so that service pipes would be clear of floor joists. East to West stanchion placing was worked out by reference to the width of each production line. North to South stanchion spacing was chosen on the basis of cost.

The architects were brought in at an early stage, and in the course of developing detailed plans suggested various amendments. Basically, they were asked to design a factory around the technical requirements defined by Work Study.

Marketing

SEEING A PICTURE 700 FT LONG

Composite View of Slabbing Mill on 15 Monitor Screens

Closed circuit television is now far from being a novelty in industry, where it is used for such purposes as seeing round corners, viewing opposite sides of a machine simultaneously, or looking at some point which an operator cannot approach for reasons of physical distance or, perhaps, because to do so would be dangerous.

An installation completed recently at the Abbey Works of the Steel Company of Wales Limited however, possesses some unusual features, and illustrates how television can provide the answer to a problem which would otherwise be difficult or even impossible to solve.

When the Steel Company of Wales decided to replace their slabbing mill with one of greater output, it became obvious that the method then in use for transferring ingots from the soaking pits to the mill would be too slow to match the increased speed of throughput of the mill. Under the existing system an ingot was lifted from the soaking pits by crane and deposited on an ingot buggy, which carried it to the mill.

To meet the need for quicker ingot transfer to suit the increased mill output, a second or shuttle car was placed on the same rails as the buggy and used in conjunction with it. The buggy is positioned opposite a pair of soaking pits, and an ingot is loaded on to it by the crane. The operator then upends the ingot on the buggy by remote control, and runs it on to the shuttle car by means of rollers. A second ingot is then placed on the buggy and the process is repeated. The shuttle car then runs the two ingots to the mill and returns to the buggy which has in the meantime moved to another pair of soaking pits.

An operator controls both the buggy and the shuttle car from a central pulpit, and the meeting of the two vehicles may occur at any point on a length of 700 ft of track, the end of which is 1,000 ft from the operator. The two vehicles must come into contact, but not collide, and the distance is too great for the operator to control them by visual observation.

A special installation of 15 closed circuit television channels was therefore supplied by Marconi's Wireless Telegraph Company Limited, Chelmsford, Essex, the design being carried out in conjunction with the engineers of the Steel Company of Wales. The 15 cameras are each equipped with a wide angle lens, and are mounted in line on one of the outside walls of the rolling mill building, facing inwards and downwards at crane rail level. Each camera surveys some 45 ft of track, and so the complete installation covers a run of approximately 700 ft. The separate camera outputs are fed to control racking in an adjacent building, and thence to the pulpit, where the pictures are displayed on fifteen monitor screens.

Several problems had to be overcome in designing the installation, particularly those of the small amount of natural light available, and the high ambient temperatures (over 160° F), which occur at times. The equipment is operating satisfactorily, 24 hours a day.

Fifteen Marconi closed circuit television channels give the ingot buggy and shuttle car operator at Abbey Works of the Steel Company of Wales a composite view of 700 ft of track.

POWER STATION EFFICIENCY

Reduced Fuel Costs Save £4½ Million

Last year, a reduction in fuel cost, equivalent to just over £4½ million, resulted from the improved thermal efficiency of the power stations operated by the Central Electricity Generating Board. The overall average thermal efficiency during the twelve months of 1958 was 25·99 per cent as compared with 25·38 per cent for the previous year. Over one-third of the 84,670 million units supplied from these stations in 1958 was provided by the 20 most efficient stations. These stations had an average efficiency of 30·23 per cent.

Their individual percentages are given in the table in the next column.

Stations	Thermal efficiency, per cent
Castle Donington (near Derby)	32·91
Ferrybridge B (near Knottingley)	31·20
Drakelow (near Burton-on-Trent)	30·84
Willington A (near Derby)	30·76
Stourport B (H.P.)	30·31
Meaford B (Stone, Staffs)	30·22
Wakefield B	30·12
Stourport B (L.P.)	30·09
Tilbury	30·04
Rogerstone (near Newport)	30·03
Marchwood (near Southampton)	30·02
Stella South (near Newcastle upon Tyne)	29·99
Portishead B (near Bristol)	29·84
Littlebrook B (Dartford)	29·73
Hams Hall C (near Birmingham)	29·52
Plymouth B	29·46
South Denes (Yarmouth)	29·40
Stella North (near Newcastle upon Tyne)	29·30
Dunston B II (near Newcastle upon Tyne)	29·08
Ince (near Ellesmere Port)	28·89

All to the Lisbon Fair

The British Trade Fair in Lisbon (29 May to 14 June) promises to be a very special display of British engineering products. The Federation of British Industries, who are sponsoring the Fair, and British Overseas Fairs Limited, who are the organisers, have been well supported by most of the leading companies in the industry and by trade associations. Several industries are holding a joint exhibit, including the motor industry, iron and steel and shipbuilding.

Most individual participants have publicised their exhibits in good time. Among the press releases to reach this office so far are Edgar Allen, whose main exhibit will be a model of a complete cement plant; the Applied Heat Company who are showing a pottery kiln suitable for biscuit, glaze, on-glaze and under-glaze decoration of earthenware, stoneware and bone china; AEI, with displays of their turbine generator and heavy plant divisions, as well as individual exhibits by member companies, including a model of Zeta shown by Metropolitan-Vickers, and a new five-channel transistorised VHF radio-telephone terminal by Siemens Edison Swan. AEI-John Thompson Nuclear Energy Company will be showing a model of a typical 150 MW single-reactor nuclear power station. English Electric will demonstrate a new water turbine.

Among the other exhibits of the most modern plant will be a comprehensive range of electric cables by BICC; dairy, food and chemical plant by the APV company; tractors, cars (the famous Aston Martin DB4) and agricultural machinery by David Brown; laboratory apparatus and equipment by Griffin and George; a wide range of engines by the Hawker Siddeley Group, Perkins and R. A. Lister (Hawker are also showing a 1/12 scale model of the Vulcan); indicating, controlling and recording instruments by Negretti and Zambra, mobile cranes by Ransomes and Rapier, and electric furnaces by Wild-Barfield Electric Furnaces. The whole show promises to be a major step forward in the promotion of British engineering products in Western Europe.

Ford May Fair

Main Ford dealers are making a strong challenge to their rivals in Lancashire. In the City Hall, Manchester, an exhibition of Ford products—cars, commercial vehicles, industrial tractors and engines—was held from 8 to 16 May. A fashion show—"to delight the ladies"—was run by Tootal Broadhurst Lee Limited.

The Ford May Fair, as it was dubbed, was organised with all the ruthless efficiency of the motor trade. Some 150,000 admission tickets were handed out or mailed to the public. Two Ford Anglias were given out as prizes.

This exhibition may well be the forerunner to a new intensive campaign of sales promotion by all large manufacturers. It promises to be quite a fight.

Electric Cables Freed

The price fixing arrangements operated by the Rubber and Thermoplastic Cable Manufacturers' Association and the Mains Cable Manufacturers' Association were terminated at the end of last month. This is the latest of a round of voluntary compliances with the Restrictive Practices Act. The Act is having a much deeper and quicker, impact on British trading practice than was generally anticipated—not without, in some cases, leaving a potentially dangerous situation.

"Survival" price wars could damage industry's capacity to develop and export successfully, and have the effect opposite to that expected and hoped for by the Government when they introduced the Restrictive Practices Bill. But the outcome may well be on the lines fore-

shadowed by Lord Chandos, chairman of AEI, in his speech to the company's shareholders (Companies in the News, 1 May, 1959, p. 572). Amalgamations and resultant dominance of a very few firms, who would become " price leaders " in each industry.

More Price Cuts

Instruments and a new plastic are the subject of the latest price reductions to be announced.

Royston Instruments, Chertsey, who have pioneered magnetic-tape data recording for industrial uses, have reduced the prices of all components of their Midas range of recording apparatus by 15 to 20 per cent. As in the case of ICI's Fluon, increased sales and higher output were given as the reasons for the cuts. A 15-channel playback, with six-channel simultaneous analysing facilities will now cost £22,000 instead of £27,500, and, at the other end of the scale, a Midas amplifier brick unit DR will cost £50 instead of £60.

Imperial Chemical Industries have reduced the price of their " Fluon " polytetrafluorethylene, better known as ptfe, by some 13 per cent. The new average price, £1 15*s* a lb compares with £5 a lb in 1948 when " Fluon " granular polymer was first sold. The steady fall in its price is the result of increased output as more applications are being developed. Ptfe has corrosion resistance and insulating properties and remarkable " non-stick " qualities which have made it suitable for use in higher temperatures than any other material.

Outlook Fair

The outlook for British exports is taking a turn for the better. The latest *GEC Export Guide* indicates that prospects are " good " in thirteen countries, "improving" in eight, "deteriorating" in eight and " bad " in only five. The markets where prospects are brighter include United States and Western Germany and also several primary producing countries, including Burma, Ceylon, Denmark, the Irish Republic and South Africa. Unfortunately, Australia is listed among those countries where prospects are deteriorating, along with several European countries. Argentine, India, New Zealand and Pakistan remain in the " bad " category. There has, however, hardly been time for the recovery in the United States to be fully reflected in better commodity prices and for the improvement which has taken place in the latter to have a decisive influence on the import policy of the countries concerned.

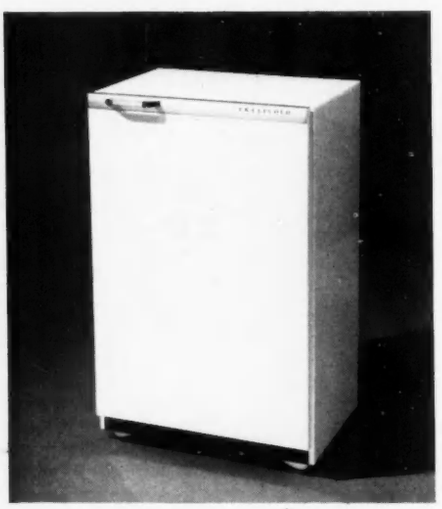
The Guide discusses the achievements of British exports to the United States since the war and the favourable climate for the continuation of this success. The United States is Britain's largest export market accounting for 9 per cent of all our overseas sales in 1958, taking £293 million worth of goods. Despite the United States recession, this represented a 13 per cent increase of British exports to the United States over 1957. The Guide concludes that the future for British exports to the United States is bright, despite probable attempts on the part of local industry to obtain greater protection. The analysis of the situation and the suggestions put forward—" to sell licence rights to United States companies to overcome tariff barriers " and " joint manufacturing "—is full of interest for the would-be exporter.

At Home

ELEGANT DESIGN

The engineer and the artist have different points of view—in the past they were almost irreconcilable. No student of art considered it possible that beauty could exist in a machine and no engineer (or at least only a very very few) could see any gain in making his ironmongery artistic; it was functional and that was that. Cast iron was the only medium in which curlicues were permissible, as witness some of the early steam engines. The succeeding generation treated them with scorn.

Of late years though, it has slowly dawned on both sides that art and engineering can be combined in good design with the added advantages of clean surfaces which do not collect dust or catch clothing. While contemporary

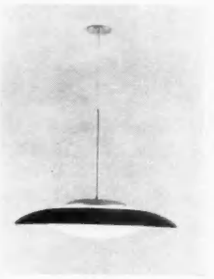


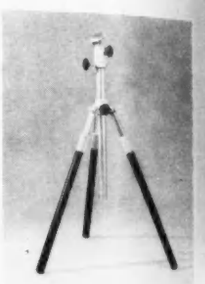
designs of domestic items still call forth a degree of scorn from the older generation, they gain mass acceptance through equally contemporary marketing techniques. One point at least in their favour—most of them need very little cleaning, a vital consideration in these days when domestic help is virtually non-existent or only available at a fabulous cost.

This year sees the award of the first " Duke of Edinburgh Prize for Elegant Design " to one of the sixteen items that have been chosen by a panel of judges from the hundreds that have been exhibited at the Design Centre in London during the past year. The favoured 16 include lighting fittings, a carpet, a table, a refrigerator, a fire, tiles, and a garden tool. Four of them are illustrated here.

The common factors in such a mixed bunch are probably cleanness of line and " usability." The judges comment on the Aristocrat socket chisel is that " it almost asks to be picked up and used." There is a curious pleasure in handling any well designed tool or weapon—is there anything nicer than the feel of a well-balanced rifle? Or a golf club? Even an ordinary spoon, knife or fork can increase the pleasure of eating, if they fit snugly into the palm. How much more can the surgeon's skill be enhanced if his instruments become virtually part of this hand.

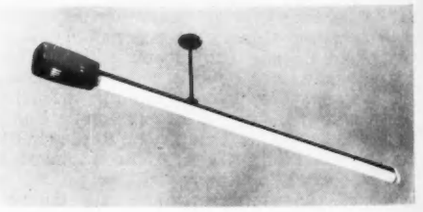
Take the refrigerator illustrated. An older generation would condemn it as plain and uninteresting; " just a box." Its name however suggests the underlying purpose—the " Packaway." Seven out of ten kitchens of the present day are cramped for space or at least have space at a premium. Therefore each item of equipment—and the number is daily growing—must either serve two purposes or must be " built in," or preferably both. All the cupboards, table tops and appliances should form an integrated whole, working surfaces at one level and easy to clean, front and sides smooth and easy to clean, floor and walls plain and easy to clean.





Hence items like the Packaway and built-in washing machines: they are functional, usable and in combination present a whole pleasing to the eye. Therefore they are good design. The only discordant note is struck by the production engineer who wants to know how they can be produced (*a*) with the tools at his disposal and (*b*) at a price at which they will sell? If these two problems are also solved, then it is indeed a good design.

The considerations of design in the kitchen apply also to the rest of the house though they are somewhat modified. Comfort plays a bigger part in the living rooms as compared to ease of work in the kitchen. Still, an item which presents a smooth surface and does not collect dust is on the way to being a good design even in the most luxurious living room. The complete sterility of the hospital is not popular in the home and the rage for steel tube furniture is not now quite so " U." However the two lighting fittings show the same cleanness of line and absence of dust



traps and unnecessary frills evident in the Packaway.

The judge's comment on the tripod, that " the distinguished appearance of this straightforward design is unusual in pure engineering," is one that engineers may be inclined to dispute. However the tripod is basically a sound piece of engineering and offers about all that the most enthusiastic photographer will require.

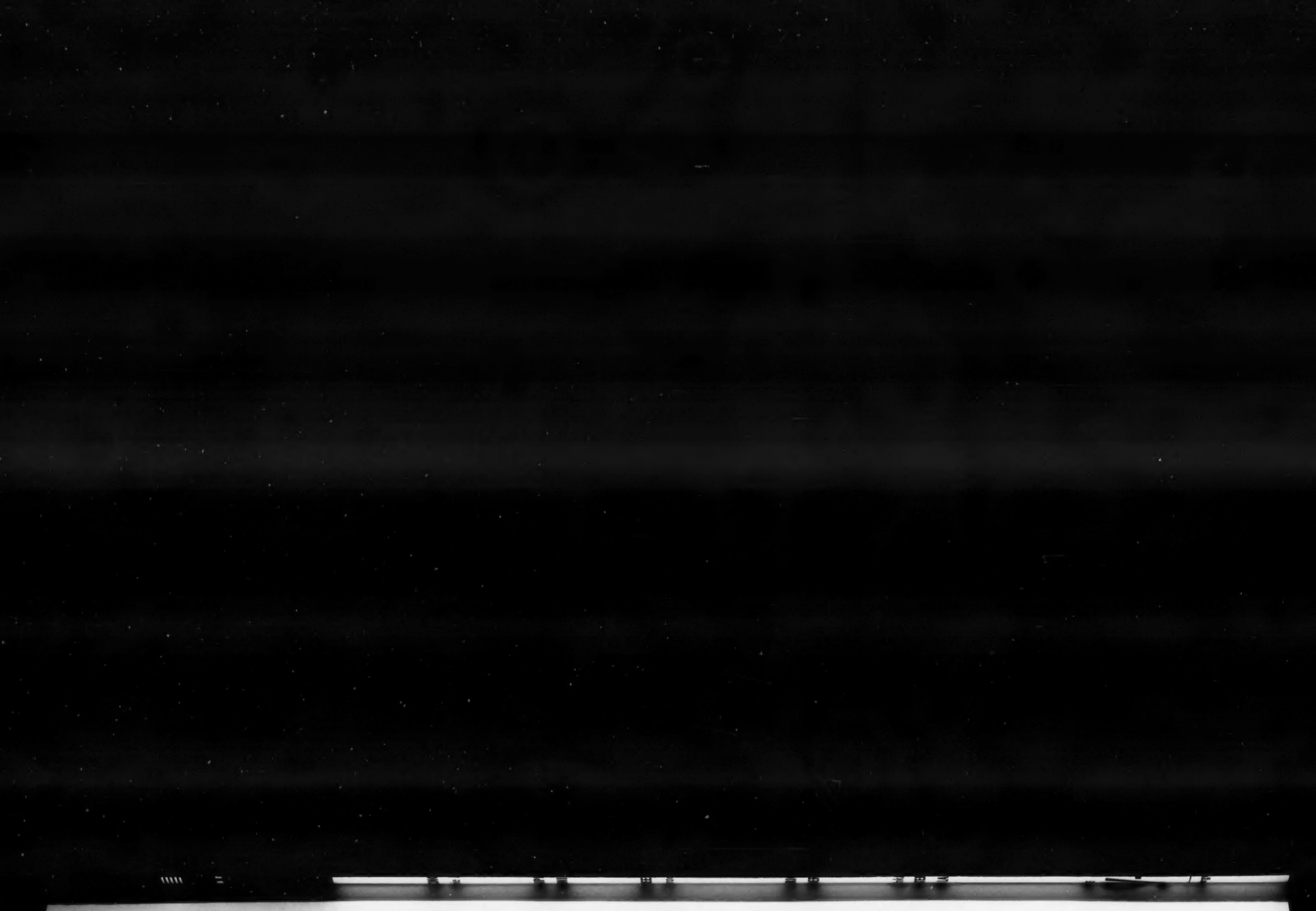
The sixteen " Designs of the Year " are being exhibited in the design centres in London, Glasgow and Bristol during May and June and in some 75 retail stores, colleges and museums throughout the country.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford Street, London, WC2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

CHAIRMAN: J. A. Dixon, M.A., A.M.I.Mech.E.
EDITOR: F. B. Roberts, M.B.E., M.I.Mech.E.
DEPUTY EDITORS: D. Fisher, Ph.D., B.Sc., A.M.I.C.E., A.M.I.Mech.E.; E. P. Ward, M.A., A.M.I.Mech.E.
ASSISTANT EDITORS: J. E. Dodsworth; W. K. V. Gale; J. T. Godfrey; D. C. E. Gribble, B.Sc.; A. A. H. Scott, B.Sc., A.M.I.Mech.E.

SUBSCRIPTION MANAGER: G. A. Roberts.
ADVERTISEMENT MANAGER: G. H. Dixon.

Annual subscription rates: Inland and abroad £5 10*s* (Canada, £5 5s). Three months, 27*s* 6*d* all countries. Single copies, 2*s* 7*d* post free.

Engineering Information Service: Assistance is available from Engineering Information Service in obtaining information, and in locating sources of information, both technical and commercial. EIS deals, for example, with names of makers and suppliers of plant and equipment, technical data on design, markets for engineering products and compilation of references to information on specific topics. Inquiries should be addressed to Engineering Information Service at the address given in the left-hand column.